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THE PLACE OF KINÆSTHETIC, VISCERAL AND LARYNGEAL ORGANIZATION IN THINKING

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In a recent debate with Professor McDougall before the Psychological Society of Washington, it became obvious that I have never made clear what I believe to be the behaviorists' position on thinking. Thinking, with the behaviorist, is and must remain until the advent of experimentation partly a logical formulation. Considerable data can be obtained by having the individual think aloud in overt terms, and considerable additional material can be obtained in late infancy and early childhood by observing the transition from overt talking to silent talking ('thinking'), but many of its phases remain inaccessible to observation until instrumentation can be resorted to.

Logically the behaviorist must formulate all psychological problems and their solution in terms of stimulus and response. He finds by experiment that word organization takes place in early infancy at a very rapid rate; that the process of word building is of the conditioned reflex type—the subject is stimulated by an object—simultaneously with the presentation of the object, the subject is stimulated by the word (spoken word, written word, touch word). The word, so far as the reaction is concerned, becomes substitutible for the object. The individual thus becomes possessed of a word universe adequate in all particulars to call out all of his organized reactions (*e.g.* all of his verbal and non-verbal

habits). Since man is a verbal animal the word is reacted to many times more often than the object itself. The word organization becomes dominant over all other organization. The throat motor segment thus becomes the controlling segment of the body.[1]

It is possibly beside the point to show that the individual does manipulate his word universe just as he manipulates his universe of objects; that trial and error manipulations bring new adjustments in the word universe in the form of judgment, verbal conclusions, propositions and the like just as they bring new adjustments in the object field—inventions, discoveries, etc. It follows, without further argument, that the individual can *plan* in words, day dream, dream and the like just as he can arrange and rearrange the objects before him—idly as in the decoration of a room, strumming on the piano, or systematically as when arranging the office furniture to admit of some new efficiency scheme.

The behaviorist has preferred to call all verbalization that goes on behind the closed door of the lips 'thinking,' regardless of whether new verbal adjustments are effected or only old habits rehearsed.

The stimulus to this behavior we call 'thinking' is obviously on the one hand the world of objects, and on the other tissue changes in the body itself.

Possibly the most powerful stimulus to action of every kind for any individual is *stomach contractions*, when food is absent. Possibly the next most powerful, in the male at least, is the *pressure et al* stimulus leading to sex response. The third is the laryngeal (chest, etc.) motor contractions in the throat of the *just previously spoken sentence;* this stimulus initiates the next verbal reaction (or the next manual or emotional reaction). In view of the fact that the hunger stimulus (contraction) and the sex stimuli (pressure, etc.) occur with relative infrequency, the laryngeal stimulus has the command of the individual's organization most of the time, except when in actual conflict with hunger and sex.

[1] 'The Unverbalized in Human Behavior.' PSYCHOL. REV., July, 1924.

Which set will become dominant when conflict occurs depends upon the parallelogram of (neuromuscular) forces.[1]

This, as I view it, is a rough summary of behavioristic contentions. The question next arises: Do we think only in words, that is, in verbal motor contractions?

It is an attempt to answer this question that forms the subject-matter of this paper. My own answer has been: Yes, or in word substitutes, such as the shrug of the shoulders or other bodily response, found in eyelids, muscles of the eye or even in the retina (I assume of course that the 'image' has been given up in psychology!) which exists in our organization as a conditioned reflex of the second and succeeding orders and put on later than the first conditioned response which is, theoretically at any rate, the word. These conditioned responses represent the abridging and short-circuiting process that goes on in all original learning.

I am inclined now to emphasize some points more or less neglected in my 1920 paper before the International Congress for Psychology and Philosophy. The present formulation tries to take account of the fact that when the individual is thinking *the whole of his bodily organization is at work*—even though the final solution shall be a spoken, written or subvocally expressed verbal formulation. In other words, from the moment the thinking problem is set for the individual (by the situation he is in) activity is aroused that may lead to adjustment. Sometimes the activity goes on in terms of (1) manual organization; more frequently in terms of (2) verbal organization; sometimes in terms of (3) visceral organization. That is, in the trial and error process towards solution sometimes (1) is dominant, sometimes (2) and sometimes (3). If (1) or (2) is dominant, progression (or possibly just 'activity' is the better word) takes place *without words*.

Let us try to make this clear by the use of our old habit diagrams, only in the diagram we are not picturing the nervous

[1] The moralists have always attempted to make the word down the other two—*e.g.* when they tell the youth: "Don't masturbate; remain pure; you will go crazy if you masturbate," etc. They might have much more success in obtaining word domination if they tied words up with more powerful substitutive reactions—*e.g.* "When erection occurs, jump into a cold tub; get up and run a mile," etc. When moralists become less deistic and more behavioristic I am sure greater success will attend their efforts.

system but units of bodily organization involving receptors, conductors, effectors, with all their subsidiaries.

Environment, presenting as it does its objects always in series, because man is a rapidly moving animal, first builds in manual organization.

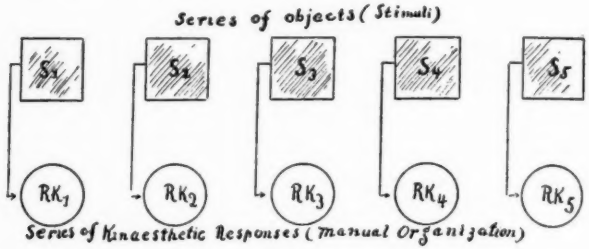

FIG. 1

But after this series has been reacted to for a considerable time (habit formed), only the initial object (S_1) is necessary to call out the total organization. An example would be: taking a walk in the dark which is ordinarily made in daylight. The change in the diagrammatic illustration is now as follows:

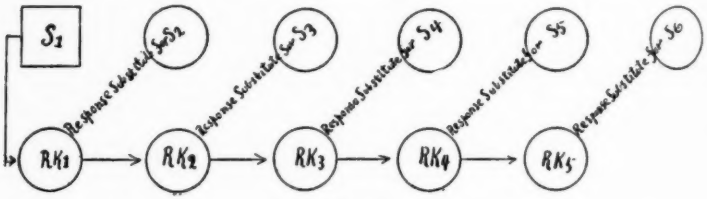

FIG. 2

RK_1, RK_2, RK_3, RK_4 and RK_5, while they are still responses as in the first case, when the object was present, now become substitutible for the object which should next appear if the original environment were present; that is, the moment they cease being *responses* (or during the process) they become kinæsthetic stimuli for the next response.

This diagram is of course a classroom device. What is not often incorporated in the diagram is the fact that the environment simultaneously organizes two other sets of processes—

viz., the *word* processes and the *visceral* processes. Psychologists before the advent of the behaviorist neglected to point out the significance of word organization and it is only within the last few years that we have had any large body of experimental results which prove that habit formation goes on in the visceral field (the field of the unstriped muscles and glands), so that to make the unit of our scheme or organization complete we will need to change our diagram. S_1 and S_2, etc. remain the objects; RK_1 indicates the manual or kinæsthetic organization with respect to the object; RV_1 the verbal organization; and RG_1 the visceral organization, respectively. It should be pointed out here that just as RK_1 becomes a motor substitute for the object S_2, just so do RV_1 and RG_1 become laryngeal and visceral substitutes respectively for S_2.

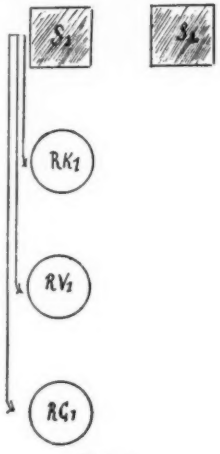

FIG. 3

The only claim needing justification here is that visceral or, more commonly called, emotional organization takes place.

Let us examine this claim at some length. On the basis of experimental work, it seems reasonable now to take the position that emotional organization takes place exactly on a par with manual organization and laryngeal organization.

We have never needed any particular 'theory' of manual organization nor of laryngeal organization. In the case of manual organization we have the observed fact that the newborn infant (and adults in new situations) slashes its arms and legs and trunk about. We have the observed fact that these unlearned acts later coalesce—become timed, spaced, regulated as to energy output (strength involved in each unit of the act). This process of organization we call habit formation.

We have the observed fact that the infant has at birth a similar repertoire of unlearned vocal acts—cries, movements of mouth, throat and chest musculature, etc. Likewise we find that organization among those units takes place—word, phrase, and sentence habits are formed.

The only 'theory' we need is a reasonable physicochemical hypothesis to account for the disappearance of those movements not essential to the adjustment as a whole, since the essential elements of the movements required must be already a part of the individual's equipment.

But when we come to emotional organization we seem to need a theory. The so-called James-Lange-Sergi theory has flourished for many years. Why, I have never been able to understand. Long before this theory became the customary psychological patter, primitive behaviorists in the Dark Ages rightly spoke of their heart, lungs, and bowels as the organs of emotional response. Apparently the sole contribution made by this group of authors was to say that the 'sensations' arising from these viscera (when in action) are the emotions.

Why cannot we now forget the James 'theory' and go back to primitive common-sense? We have a great mass of unstriped muscles (neglecting for brevity's sake that some striped muscles are present)—in stomach, heart, lungs, diaphragm, blood vessels, glands, excretory, and sex organs. It would seem fair to call the whole set viscera. Could we not drop the concept of emotion and speak hereafter of *unlearned visceral behavior* and *learned visceral behavior* (visceral organization)? As unlearned visceral behavior of the pattern type we would speak of heart beats and circulation, respiration,

defecation, urination, tumescence, peristalsis, stomach contraction, duct gland activity (salivary, etc.), ductless gland activity and *whatever else observations* show to be present. Likewise, in the whole visceral mass we have less highly organized responses corresponding to the 'random' activity of arms, legs, and trunk and of the vocal musculature.

It seems to me that the evidence is at hand to show that these ('random') visceral responses become organized into habit systems just as is the case with responses in the striped muscles. Lashley has shown the presence of conditioned responses in the salivary glands, Pawlow and others in the stomach glands; several others have shown that the respiratory system and the heart system can be conditioned. Cason has shown that the pupillary reaction can be modified. The work on the so-called conditioned emotional reaction of Watson and Rayner would seem to fall in the same field as would the whole rich field of observation made by Kempf. Possibly even the sweat glands and the ductless glands show similar stages in habit formation.

Every-day observation gives us the best examples. Infants can be trained in eliminative functions when they are from two to three weeks of age; our adult stomachs get trained to call for food at definite hours and for small or large amounts of food. Possibly sex gives us our best examples of visceral habit formation in learning to delay the orgasm. I am inclined to think now from some recent observation that jealousy is another highly organized built in (learned) bit of visceral behavior.

The extent to which accurate and efficient manual and laryngeal acts of skill are dependent upon suitable organization in the visceral field has never been sufficiently emphasized. Probably as many drives have been spoiled on the tee by a slip in the intestine, a dry mouth, a bit of gas pressure, as by a bent knee or taking the eye from the ball.

Just as we can never truthfully speak of behavior being completely manual or completely laryngeal, so we can never speak of purely visceral behavior. We do, however, speak of manual organization becoming dominant, as when the

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individual is doing fancy riding on a bicycle; or dominantly laryngeal, as when a speaker is lecturing. Just so can we speak of visceral organization dominating in sex, in fear reactions, in jealous exhibitions, blushing, etc. We can speak of both visceral and manual organization dominating in fighting; of both visceral and laryngeal organization dominating in *flirting*.

With this justification of how visceral organization takes place we should be prepared to admit logically its place (in minimal or subdued form) in the activity we call thinking.

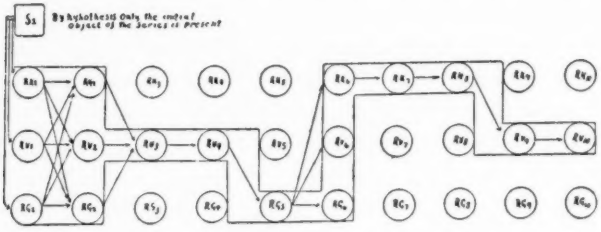

FIG. 4

The diagram makes clear the view that thinking involves all three sets of our organized reaction systems.

Please note that RK_1 can arouse RK_2, RV_2, RG_2; whereas RV_1 may call out RK_2, RV_2, RG_2; and RG_1 either RK_2, RV_2 or RG_2; and that all of them serve respectively as kinæsthetic, laryngeal or visceral substitutes for S_2, the next real object in the series of objects originally producing the organization. Note that in accordance with the schema, thinking activity may go on for a considerable time without words. If at any step in the process the RV organization does not appear, thinking goes on without words.

We will assume that the individual is in a situation where he must think—he cannot overtly 'act.' In other words, we assume that action in all three realms (RK_1, RV_1 and RG_1) is *minimal*, *i.e.* does not show as overt behavior.

It seems reasonable to suppose that thinking activity at successive moments of time may be largely kinæsthetic, vocal or emotional; that kinæsthetic organization may become

dominant for a time, then, as conflict arises, the vocal; if both are blocked, the emotional. By hypotheses, however, the final response or adjustment, if one is reached, must be verbal (subvocal).

This line of argument shows how one's total organization is brought into the process of thinking. It seems to the writer at any rate to emphasize a little more clearly that manual and visceral organization is available for thinking even when subvocal or overt behavior is not taking place.

We thus think and plan with the whole body. But since, as I pointed out above, word organization is, when operative, probably usually dominant over the remaining organization, it seems, if we must still use the term 'thinking,' that it is after all a reasonable use of metonymy to maintain that '*thinking*' *is largely subvocal talking*—provided we hasten to explain that it can occur without words.

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PARTICULAR FEATURES OF MEANING

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Meaning we have elsewhere[1] defined as a sequence or procession of events, involving the instigation of a consequent by a partial detail of its former antecedent. The following experience will serve the purpose of concrete illustration. I had entered the lecture hall with my friend, who opened the door while I preceded him. After I had taken a few steps slowly, a figure came up alongside me and I at once began to speak, continuing the thread of our previous conversation. Then I abruptly stopped speaking, as the strange young woman who was just passing me went on ahead and up the stairs. I had 'thought' that the figure alongside me was my friend, and had at once continued the conversation that had been interrupted by our entrance through the big door. The perception that it was not my friend, but a stranger who looked at me quizzically as I spoke, stopped my flow of speech at once.

In ordinary terminology, the appearance of a shape alongside me *meant* that my friend was again within conversational distance—the shape *meant* my friend. What, as a matter of fact, did exactly occur? Nothing, except that the appearance of the figure started my conversation going again. That was what it was for the shape to have the particular meaning that it did. It *led to* or *instigated* another event, which was the same event (an event in the same class) that would have occurred had my friend been entirely there. There was no discernible peculiar 'conscious content' to be designated as the *meaning* of the shape—the meaning was its efficacy in releasing my speech mechanism rather than in making me dodge or salute. And at the point where *its meaning changed* all that happened was that now sufficient

[1] 'Meaning and the Psychophysical Continuum,' *J. Phil.*, **20**, 1923; 'Psychology of Functional Neuroses,' D. Appleton and Co., 1920.

details appeared to set off a different adjustment on my part—to instigate a different consequent.

It is to be noted, however, that this is not a 'motor theory' of meaning, although the particular illustration chosen does involve a motor event. The instigated consequent, redintegratively evoked, may be of any sort whatsoever—visual or auditory object, image, feeling, attitude, motor adjustment, pure thought. Any of the 'natural events' that can be verified as comprising our phenomenological world may, theoretically at least, participate in a meaning sequence, either as antecedent, as past context, or as consequent. And meaning is not any one of these merely, but the total situation, in which may be discerned, for purposes of analysis and description, the 'significant' (the present partial detail), the 'signified' (the past context), the 'signification' (the consequent), and the 'signifying' (the process of instigation).

Native and Learned Sequences

In a psychological account of meaning, furthermore, we must distinguish between acquired and original sequences, between learned and native reactions. Meaning may be considered as entirely connected with the former—with the learned, the acquired, the conditioned. A reaction or sequence of the reflex or purely instinctive type shows no explicit sign of meaning, in the sense in which the term is here used. Native reactions are not to the *meanings* (the signified) of events, but to the events themselves. They are therefore physical, not mental sequences. Thus the blinking of the eye in response to a sound is not a reaction to the meaning of the sound but to the sound itself as complete and immediate event (assuming that this auditory-motor reaction is a true reflex).

In many instances, indeed, native reactions are themselves essential parts of the sensory or perceptual event, as has long been recognized. Thus the attitude toward a color is an essential part of the event 'seeing the color.' Although reactions or sequences of the native sort are not *meaningful*, it does not of course follow that they are not *appropriate*

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or *useful*. They may be appropriate, and this is at least part of the reason why they are perpetuated in natural selection. But their origin is philogenetic, not ontogenetic. Some observers, Hall or Jung, for example, will be inclined to say that it is to a *racial meaning* that the native reaction is made; that the experience of the race has given the event a real meaning. But for the present I prefer to restrict meaning to the efficacy which events acquire through the experience of the individual, either directly or indirectly.

In the suggestion of racial meanings we approach the doctrines of Hering, Ribot, Semon and others, that there is a close relation between *heredity* and *memory*. Heredity does for native reactions what individual past experience accomplishes for learned sequences. But the *mechanism* involved in the two cases is presumably different, although Semon believes that both heredity and memory work under the laws of the engram and its ecphory.

Individually experienced events acquire meaning through the redintegrative mechanism. The wide spread and relatively independent adoption of this mechanism in recent years is surprising. In the author's mind it was formulated some ten years ago, apparently on the basis of Bradley's critique of Hamilton, and under the influence of the general dissatisfaction felt with the prevailing account of symbolism, the unconscious, and the conditioned reactions. Meantime the mechanism has been vigorously developed by others under various names, such as 'law of ecphory' (Semon), 'mnemic causation' (Russell), 'law of combination' (Woodworth), and it had already been clearly expounded by Burke and others.

The burnt child dreads the fire because he has survived it, and through the redintegrative mechanism the single detail now produces the final previous reaction or consequent. Much difficulty has been encountered in the account of this process of learning, as by Meynert, James, Russell, Holt, Watson, and Kantor. The difficulty arises from their taking the fire as the stimulus, the reaching reaction as one response, and the movement of withdrawal as another. The problem

then becomes, how is it that making neither reaction, just looking, becomes substituted for the two reactions, reaching and withdrawal? On this basis there is bound to be difficulty.

On the other hand, the fact is that the first or original situation was reaching for the seen candle and experiencing pain. This total event was followed by withdrawal. Now the mere sight of the fire produces an avoiding reaction, or at least an avoiding tendency which negates such an event as the reaching reaction.

In such a process there is really a *formative* mechanism involved. Something happens in the reaction systems of the individual, which remain changed as a result of this experience. But, unless we definitely assume the inheritance of acquired characteristics (as Semon does), native reactions disclose no such formative mechanism. They do not follow the laws of mnemic causation. Instead their production is through variation and selection. Thus the resemblance between heredity and memory is not in virtue of their *mechanisms*, but follows merely from the nature of the practical *results* which both achieve.

Both result in appropriate reactions, but appropriateness in this sense is not a psychological but a biological category. Just what appropriateness, in a psychological sense, is must be asked when such concepts or phenomena as harmony, fitness, congruity, contradiction and the like are examined in detail. But it is at least clear that a distinction must be made between 'a feeling of fitness' and 'biological utility.'

Whatever meaning may be attributed to events in their instigation of native reactions, it is a type of meaning that is confused with *value* or *importance* in the objective sense. To say that the event has a meaning in the life of the animal, in this sense, is only to say that it is important that an adaptive response be made and is made. The event has associations, but association must be distinguished from meaning in the psychological sense.

If, then, we are agreed that response to the meaning of events involves always acquired or learned sequences, we must at once point out that not all sequences dependent on

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learning are responses to meaning. Thus a native *tendency* may through repetition be rendered more fixed, definite, certain, and prompt. But meaning is not involved in such learning. Again, in rote memory, learning results in the establishment of new bonds. Contiguous items of the memorized materials or reactions are linked together, so that one leads to the other, as in reciting the alphabet or a series of nonsense syllables. That *A* should lead to *B*, that it should have associative connections, is the result of learning. But it does not follow that meaning of any kind is involved in mere associative sequence.

In order for learning to display the characteristics of meaning, a particular pattern of associative action seems to be required. This is that type of learning in which a partial detail, as *C*, of a complex event *ABCDE*, touches off a complete response *XYZ*, which formerly (either as native or acquired) was touched off only by the complete event *ABCDE*.

Redintegration and Conditioned Reflex

In another connection [1] I have already pointed out certain reasons why 'conditioned reactions' are not identical with the redintegrative sequences here considered, but are instead only a special case of them. The following distinctions are to be made. The conditioned reaction principle assumes that some first reaction is made to an original stimulus or event. This is the unconditioned response. To this response is then supplied another stimulus, by associating this latter with the primary stimulus.

But in the redintegrative sequence no distinction of fundamental reaction and primary and secondary stimulus need be made. The response may be instigated originally by all the details of a stimulating (antecedent) situation, by a synergy of various stimuli, for the very first time. Thereafter the occurrence of one of the details provokes the total reaction. Clearly this is very different from the bare scheme of the conditioned reaction, which is only one case of the more general principle. Redintegrative sequences need not in-

[1] Psychology of Functional Neuroses,' D. Appleton & Co., New York, 1920.

volve reflexes, in any acceptable sense of the term, nor is their production dependent upon frequent repetition.

Semon's account of the action of 'engrams' is especially interesting in connection with the redintegrative account, even though the latter requires no neurological counterpart, which would at best be but a correlated event. But the general features of Semon's account are so nearly identical with the redintegrative mechanism that it may be well to state his three fundamental laws. These are as follows:

1. The engram left by a complex stimulating set of details is a single engram, and tends to be aroused in total form thereafter.

2. For reinstatement of the engram the total stimulating situation need not be present thereafter, but any part, or at least certain parts, of the original stimulating situation will suffice to arouse the total engram—to 'ecphore' it.

3. One part of an engram may ecphore another engram in the same way that part of the stimulating situation reinstates the total engram.

Although Semon develops this only as an account of memory, and is preoccupied with the 'engrams' and the speculative neurology associated with them, the redintegrative mechanism involved in his description serves adequately also as an account of thought. However, just as in the case of the neuroses something in the way of motivation or direction must be added to this mechanism, so also in thought (as reasoning) something in the form of 'aufgabe,' 'set' or 'determining tendency' must be worked out in its detailed application and influence. Inasmuch as details belong to various engrams, we must explain why, on a given occasion, the particular one rather than others functions. In another connection, when an account of reasoning as a form of thinking is presented, it will be shown that motivation is only a more general and inclusive form of redintegration, in which two clues, the specifying and the instigating, function instead of one only.

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Is 'Telescoping' also Meaning?

A characteristic human and animal reaction pattern is that which Jennings has so clearly described in the case of some of the microscopic forms. It has sometimes been called the 'telescoping' of reactions. Thus if a stimulus of moderate intensity be applied to a Stentor, it waves its oral end away. Upon repetition of the stimulus one or more times there ensues instead a contraction of the stalk. With continued application of the stimulus, neither of these reactions occurs, but instead the organism unfastens itself and moves bodily away. On a subsequent occasion the first application of the stimulus is followed at once by the final step of this reaction series—Stentor moves immediately away.

In one sense this is only a case of varied reaction to the same kind of stimulation, the variation depending essentially upon previous stimulation and its after effects. But it has also been described by some writers as the telescoping of a series of reactions by the dropping out of the intermediate steps. In this way the constant or repeated stimulus *S* leads originally to reactions *A-B-C-D*, but finally it leads only and directly to *D*. Some observers might at once conclude that the stimulus has now acquired a *meaning*. Or a devotee of the motor theory of perception might suggest that the stimulus has now acquired a *new* meaning.

It seems clear, however, that meaning can be attributed to this process only if the state of the organism be included as a stimulus. If this is done we may say that the reaction to the later appearances of the peripheral stimulus are not determined by *S* alone but by *S* plus an additional experience or context—viz., an intraorganic condition. But it is not clear that the state of the organism is properly to be called a stimulus—is it not instead more properly only an essential part of the reagent? If not, then the whole distinction between reagent and stimulus must give way. If the organic state is part of the reagent, it can scarcely be called a meaning. Perhaps, on such grounds, the most that we can say is that the telescoped series is one of the vague grounds

on which what we call meaning may develop in higher forms of organisms.

There is, however, the possibility that this type of response more closely resembles the ordinary chain reactions, in which the first response becomes a stimulus to the second, and so on. The intermediate reactions or events may of course be much abbreviated, may become tentative or incipient only, or the overt reactions may be definitely inhibited by the beginning of the later acts, which interfere. The earlier steps will thus be supplanted in observation by the ensuing steps which more overtly occur. Whether or not such an account will adequately describe what we have called a meaningful sequence or act, is a pertinent question, to be answered presumably only on the basis of direct observation. It is even possible that what has been here called the redintegrative mechanism could be given such an explanation.

Such an explanation has sometimes been offered, as by Roussy and Lhermite, in the case of the neurotic conduct. These authors assume that between the stimulus and the reaction there occurs what they call 'a remembered emotional state,' of which the symptom is the expression. Dejerine and Gauckler also assume 'the revival of the image,' which image it is that instigates the symptomatic response. But the redintegrative account seeks to get along entirely without these interpolated but telescoped processes, and this is indeed its special virtue.

We can rely for our judgment on two criteria. In the first place we may appeal to observation, to what is called introspection. If such observation does not reveal the intermediaries, we may then either insist that they must nevertheless have been present, in such fleeting form as to escape report, or else we may say that since the evidence for such intermediaries is missing, we are at liberty to work on that assumption which, while adequate, is least complicated and makes the fewest suppositions and conjectures.

Of these two assumptions, the simplest is surely not that of the unnoticed presence of intermediate events, but instead that of the simple sequence of the mnemic sort described by

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Semon (omitting, as purely theoretical, his notion of the engram). If the reactions to details may be the same as those that would be present if the total were operative (if engrams function as total patterns and are aroused by details of the stimulating situation) this is enough to explain the significance of signs as well as the reinstatement of the neurotic symptom.

Woodworth ('Psychology,' footnote, p. 405) suggests an explanation of the 'telescoping' process which lines it up with the redintegrative mechanism, called by him 'the law of combination.' The explanation is as follows:

"When, however, this indirect linkage between stimulus and motor response is frequently exercised, short-circuiting takes place and the stimulus word arouses the motor response directly. Short-circuiting follows the law of combination very nicely. Let a stimulus *S* arouse an idea *I* and this in turn a motor act *M*. *S-I-M* represents the linkages used. But undoubtedly there is a weak preëxisting linkage directly across from *S* to *M*, and this gets used to a slight degree, strictly according to the conditioned reflex diagram, with *I* playing the part of the effective stimulus in arousing *M*, and *S* the part of the originally ineffective stimulus. By dint of being exercised in this way the linkage *S-M* becomes strong enough to arouse the motor response directly, and *I* is then very likely to be left out altogether."

If this account is accepted, the telescoping or short circuiting process falls sufficiently in line with the redintegrative mechanism to be considered an instance of the acquisition of meaning.

Levels of Meaning

That there are levels of meaning is suggested by a classification of neurotic symptoms, which classification has certain advantages and a definite theoretical suggestiveness. Such symptoms may be classified as belonging on the postural, the autonomic and the cortical levels. In some ways this distinction resembles the ancient threefold division of mind into intellect, feeling, and will, and it must be said that the old distinction has many advantages.

Thus in the case of the neuroses, postural symptoms yield paralysis, contractures, motor automatisms. Autonomic

symptoms give anxiety states, depressions, chronic fears. Cortical symptoms yield fixed ideas, obsessions, thought fixations, and the like. In the same way we may point out three levels of meaning, and corresponding to these, three different ways of understanding an event.

1. On the postural level meaning is concerned merely with our conduct, our overt behavior and *handlungen.* Meaning shows itself through appropriate muscular action or adjustment. I understand or know the meaning of a carburetor, a lock, a stove, when and in so far as I can handle it. I understand a mechanical puzzle, that is, know its meaning, when I can take it apart or put it together. In just this way the horse knows the meaning of a whip or of a call, the dog knows the meaning of my whistle or of my stooping gesture, when he reacts in the appropriate or standard or useful way. The redintegrative basis of such understanding is evident and is clearly revealed by the history of the learning process.

2. On the autonomic or affective level I know meaning when I get the appropriate feelings, attitudes, and emotions. Here meaning is very close to *value* and this is the excuse for the occasional attempts to identify meaning and feeling. On this level it is possible for me to know the meaning of music, of a dance, a statue, a poem, and of various figures of speech. Again, as in most æsthetic reactions, the redintegrative basis is apparent.

3. Intellectual or cognitive meaning is the presence of an appropriate context of concepts, images, references, relations, notions, ideas, associative tendencies, and in many cases of appropriate naming responses and of varied secondary meanings. Thus we know the meaning of a scientific law, of a mathematical proposition, of a telegram or code, and of many signs and symbols. The redintegration is of symbolic processes rather than of autonomic or postural acts.

Naturally these distinctions are not sharply isolated in experience. In actual cases, as in getting the meaning of a telegram, meaning on all three levels may be present; or on more than one level, and unequally on the various levels.

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But the distinction is a useful one, and developes neatly the general theory of meaning in its redintegrative aspect. Meaning may be unconscious or automatic on the postural level, emotional on the autonomic, cognitive on the cortical. Music as an example, may be either produced, enjoyed or understood.

Obstruction or failure of meaning on one level throws its process up to a higher level. If the cook tries to shake the stove and it does not work, meaning shifts to a higher level, the emotional one. She becomes enraged and by virtue of her rage she shakes harder and in random and unstereotyped ways, and may thus succeed in moving the grate. But if this shift does not work, a further shift to the level of thought comes about, and she examines the mechanism, recalls previous experiences, sends for assistance.

On the other hand, meanings which function adequately tend to degenerate to lower levels as they become perfected. This possibility of shifting to lower levels, the tendency to automatization, has many advantages. This is essentially what Titchener has in mind when he speaks of the law of reduction in imagery. The falling away of imaged context and the carrying of meaning by kinæsthesis becomes on this account intelligible. It is the shift of meaning from the intellectual through the affective to the mechanical level. But the purely introspective account fails to do justice to the dynamic and functional processes, which are revealed only when due consideration is given to the temporal aspects, the sequential feature of experience.

Meaning and Logical Implication

The redintegrative account of meaning applies even to natural signs or natural laws. Three equal angles *mean* three equal sides, in a triangle. This, I suppose, is a case of 'logical implication,' or 'geometrical necessity,' or 'matter of fact,' or 'association of ideas' as one may prefer. But no matter what vocabulary is employed, the simple fact is that 'three equal sides' is *part of a total* which includes 'three equal angles.' It is the relation of part to whole that under-

lies not only the mental process but as well the logical or physical fact. Hence the *meaning* or significance due to causal connection, or involved in logical implication is not unrelated to meaning in the simpler psychological sense. The psychological observation is directly relevant to the logical problem.

It is not necessary to go through any 'universal,' or through any additional premise. At best such additional premise or universal would only indicate the whole or total, which is not something more than the parts and their relations but just these parts in relation. Judgments are then merely statements of the meaning of signs. Thus 'The humanity of Socrates is a sign of his mortality' is all that is involved in the classical syllogism. Meaning leads directly to judgment, and at least to that extent logic is dissolved in psychology. Cannot all syllogistic reasoning be thus considered as a matter of reading and reporting the meaning of signs?

In this way fire means smoke, sand in the sugar means broken teeth, a north wind means cold weather. Hume's definition of a sign as 'nothing but a correlative effect from the same cause' should be modified to read, 'A sign is nothing but part of the same whole.' This eliminates the more or less mystical notion of *cause*, which was a difficult problem even for Hume.

When one end of a tilt-board is elevated, the other is depressed. The elevation becomes a sign of the depression. The remaining premise is simply the affirmation of the nature of the total situation: 'When one end of a tilt-board is elevated the other is depressed.' This assertion merely states the nature of a rigid body and it is far from essential to the deduction of meaning, which indeed must of necessity precede it and make it possible.

This is why the third premise is so often suppressed, and also why it seems so strange and affected when it is proposed to students of formal logic. It is actually not a part of thinking, for thinking is passing from parts to consequents, in the light of antecedent wholes. The syllogism in this case rests merely on the nature of a rigid body, and

inference from one detail is only taking the one as the sign of the other, or of the whole.

This similarity of the meaning function in thought and action, on the one hand, and in the implications of natural science and mathematics on the other, suggests that the distinction between thoughts and things, which is usually so sharply drawn, is less definite and rigid than is usually supposed. At least from the psychological point of view, we deal from the very beginning with *events*, or with what has often been called *experience*, which word has been much maligned because of the mystical temptations it offers.

But the seeing of an object is not, psychologically, what we subsequently analyze it to be in logical terms. It is a total event. After it has happened, and after considerable further experience has been brought to bear upon it, we distinguish within it the thing seen, the seeing, the seer, the reaction or attitude, and the memory trace. But in the event itself all these were one fact.

We classify events into the physical and the psychic, the real and the unreal, the objective and the subjective, on the basis of what we later learn about them, not on the basis of their immediate characteristics. In the very appropriate words of Herbart, "The difference between soul and matter is not a difference in the nature of simple essences, but it is a difference in the manner of our apprehending them" ('Text-Book of Psychology,' Trans. Smith, p. 121). The distinctions are convenient, and perhaps this has some implication for epistemology and metaphysics, as it has also for commerce and industry. But in the interests of practical life and under the dichotomizing tendencies of verbal language and legal precedent we ignore the great region which lies between our two distinctions—that great field of intermediate events which completes the psychophysical continuum.[1]

In a very real sense the notions of 'neutral stuff' and of 'essence' which the New and the Critical Realists have developed have an importance for psychology. The events with which psychology starts, as is the case also with all

[1] 'The Psychophysical Continuum,' *J. Phil.*, 13, 1916.

other sciences, are *neutral*, in the sense that they occur before the analysis of subject-object, attribute-substance, term-relation, action-agent, and the like, has been made. These analyses themselves are only other events.

It is *events* which have meaning, or through which the function of meaning is realized. The image, the attitude, the feeling, the word, the gesture are events, just as truly as are the table, the rainbow and the explosion. The organism does not become conscious of objects through the intermediation of states of mind. Mind, organism, and object are all there in the perception. It is just as true to say that the color becomes conscious as it is to say that the spectator does so. What is true is that the *situation* becomes conscious—it is a conscious situation.

Perception and Thought

Meaning is never complete except in original perception, that is, in the first known occurrence of an event sequence. Smoke means fire when it is actually attended by it, and here the meaning is *complete* or actual. Such a condition, that is, the field of natural signs, is the origin of all meaning. But in thought the meaning is *incomplete*.[1] It may nevertheless be *effective*, in the sense that it leads to further developments and stages, which in turn may also be incomplete and sketchy, yet effective also. But a *final* meaning must be full and complete and *realized* in perception. This is perhaps what Dewey means by the moving to and from the meaning, the meaning is suggested by a particular or detail, and from the meaning we return again to perception for verification, for completeness. Artistic thinking is not thinking freed from reality. It is thinking that strays far beyond perception and does not dip back into it again. That is, its meanings are not finally realized in perceptual completeness, or, in Dewey's terms, are not verified.

The complete signification of a perceptual detail (datum) is then the total perception of which it is originally a part, and this would also include the postural and autonomic

[1] 'Symbolic Relations in Thinking,' *J. Phil.* 20, 1923.

events. But the rule is that in thought meanings are usually partial, and this is why their introspective description has seemed so difficult and unsatisfactory. The *effective details* or elements also vary from time to time (and from person to person, if we care to go beyond individual report), and this is what accounts for the irregular verdicts, the imageless reports, the feelingless accounts, the reports of meaning without sensation or image, even of the kinæsthetic and organic varieties. Meanings *exist* only in nature, but they *function* in thought, and to function they need not be complete.

If in thought a meaning is complete, we call it either a perception or an hallucination. Which it is cannot be determined by the analysis of its constitution or components, but only by its place in the accepted scientific order or in the socially accepted practical world of history. It must be checked up by various devices which we agree to employ to indicate the physical, or by the social devices which we agree to employ to indicate the real or objective.

The *migraine figure*, a familiar optical event, is an excellent example. It is, as an event, complete and vivid. It has attributes of order, duration, pattern, extent, location, quality, liveliness and obstinacy. Yet it can no more be subjected to the test of *other senses* than can the rainbow. It is even more real than most visual objects, real, that is, in the sense of persistent and unavoidable. One sees it with eyes either closed or open. As a phenomenon it has no present meaning except its name, for there is no special context in which it occurs. But one part of it definitely means the rest of it. The meaning is *complete* when the remainder actually follows. Its meaning is incomplete, but effective, in so far as one postpones his work or prepares to rest or exercise, or feels depressed at the prospect. The identification and naming are what we have called cortical meaning. The preparations are postural, and the depression is autonomic.

Completeness and Incompleteness

What we call traces, or images, or thoughts, of objects and events are distinguishable from the originals which they

mean only by their incompleteness. Thoughts are fragments or details of previous totals. Hence there is no special mystery in the relation of present to absent objects, any more, at least, than there is in the relation between one perception of an object and another perception of it. In a sense it is not the same object, even when continuously regarded, just as, in a sense, a tree is not exactly the same tree on two different occasions. But just as truly as the tree remains the same tree, or two perceptions of the same object are the same perception, just so truly is the thought of an object only a *part* of that same object.

The *thought of* an absent object is a part of the object, in just the same sense that the tail of a rabbit that has plunged into a hole is a part of the original rabbit, of the rabbit formerly seen; or in the same sense that the glimpse of an object seen through a lace curtain or a smoked glass reveals part of the object seen in greater completeness when the screen is removed. We pursue the rabbit whose tail alone is seen, just as vigorously as we did when his whole body was in view. The seen tail has now become a thought, inasmuch as, being part, it functions for a previous whole. We fear the burglar behind the curtain no less than when he is in full view. We fear the fancied or remembered burglar also, in just the degree to which he is completely present.

If now it is asked what *makes the difference* between the complete burglar (of perception) and the incomplete burglar of thought, the reply is that the question leads us beyond psychology. We must look to physiology, or to physics, or to the efficient police force for such explanations. The world of thought does not differ from the world of perception except in completeness, so far as description is concerned. It is only in so far as collateral explanations may be found for the differences in completeness that the two are to be practically distinguished.

It must be noted, however, that the detail present in thought may not be a very conspicuous detail of the immediate perception, of the historic event. It may instead be a trivial and accidental detail, even what we call an 'associated'

detail, such as a word, gesture, an attitude, a specific feeling, an imaged article of clothing. But any and all of these were part of the original event or situation. Whatever be the detail, in so far as it functions in place of the total of which it was originally a part, it is a thought.[1] In so far as it does function, it functions redintegratively, leading to action, feeling, further thought, or to new events of perception. Depending on the sagacity with which it is chosen, it functions correctly or uselessly. But even when it functions uselessly or detrimentally, as in hysteria, and in dreams, its status as thought remains unchanged, and the redintegrative mechanism underlies its instigatory efficacy.

Thus the distinction between thought and perception is gradual, not sharp, even as language usage suggests. A *false* perception is often described as a *thought.* If the object in the distance is mistaken, we may say indeed that even this was perception, but the victim of the error is likely to reply that he only *thought* it was a house, whereas he now *perceives* it to be a haystack. What marks the line or moment between these two? Not the process itself, but what is later learned about it or correlated with it.

Thoughts and Things

Suggestions of this distinction between thoughts and things are to be found in Edmund Burke's 'Essay on the Sublime and Beautiful,' written nearly two hundred years ago. Burke concludes his essay with a section on the way in which words are able to affect us. This involves him also in a comparison of the effects of poetry and painting, but we are especially interested in his account of the mechanism of verbal efficacy.

The general account which he gives is to the effect that words are *substitute stimuli* for other objects or occasions with which they have occurred, for situations of which they have been partial details. He definitely rejects the theory that words operate by first arousing images of those objects or occasions. Instead, having previously been part of a situa-

[1] 'Symbolic Relations in Thinking,' *J. Phil.*, 20, 1923.

tion in which the object was also present, the word now functions, as partial stimulus or detail, to instigate the same reaction as that which might be instigated by the total context.

"Such words are in reality but mere sounds, but they are sounds which, being used on particular occasions, wherein we receive some good or suffer some evil, or see others affected with good or evil; or which we hear applied to other interesting things or events; and being applied in such a variety of cases that we know readily by habit to what things they belong, they produce in the mind, whenever they are afterwards mentioned, effects similar to those of their occasions."

The power of words, to put it concisely, comes from their signature value, from their substitutive rôle, from their vicarious functioning, their redintegrative efficacy. Burke wrote at least a hundred and fifty years before Pawlow came to the rescue of the motor behaviorists. If this 'nominalistic' account of the effect of poetry be acceptable, then there is no reason why it may not be extended to cover the thinking of a more prosaic order.

But a slight correction of Burke's account is all that is needed to extend the *substitute* rôle to other objects as well. This correction consists in pointing out that Burke was in error when he drew the sharp distinction between words and what he calls 'natural objects,' by which he presumably meant 'visual objects' or 'tangible objects.' But words also are natural objects. They are, however, 'auditory objects,' and as such they are also brief and fleeting.

Bertrand Russell has already insisted at some length that words can only be understood when they are recognized as being 'physical things.' If one once really appreciates the fact that a word, whether spoken, heard, written or seen, is a natural event, an actual physical object, in the same class with chairs, houses, cyclones, and rainbows, it is not difficult to agree that a physical event may be all that constitutes a thought. Once this is done, we have attained the end for which we have been seeking, the recognition that thoughts are characterized not by any peculiarity of their intrinsic nature or make-up, but solely by their function.

Confidence and Development

Other topics call for consideration at this point, but we can for the present only indicate their character. The first is the fact of confidence or belief, and its varying degrees.[1] Certainty varies with the fulness or completeness of signature. If only a small part of the whole is present, certainty is low. It rises the more completely the whole is reproduced. Certainty of judgment, that is confidence or belief, varies with the amount of data, and it is this also which gives the transition from judgment to full perception. Clouds are the sign of rain, but if only this element is present, the certainty is low. Other facts are also indicators, that is, partial conditions, and the whole is there only when the rain is there also. Primitive magic erred by placing too great confidence in minor details. We progress beyond this either by more complete enumeration of signs or by the discrimination of degrees of relevance. Primitive magic thus resembles the reliance on secondary criteria in judgment experiments. But the general problem of belief is so far reaching that it cannot be further considered at this point.

The second point has to do with the genetic aspect of meaning. Meaning seems in a sense to develop from identity, through similarity, to contiguity, as the basis of its occurrence. This fact is perhaps the basis of Russell's curious conviction that meaning has always a primary imaginal origin. Thus early language, especially graphic language, was imitative or reproductive, pictorial. Later a definite but minor similarity sufficed between sign and signified. The pictographic stage in time gave way to the use of conventionalized graphs and more or less arbitrary signs, through contiguous association. Letters, words, inflections, affixes, internal word variations, differences of order, and the like, all come to be meaningful. D–O–G no longer portrays nor even resembles either the sound or the animal for which it stands.

In the same way the 'representative image' gives way to the associated detail as the 'bearer of meaning.' Now similarity is redintegrative in its basis. It is the presence of a

[1] 'Experimental Studies in Judgment,' *Arch. Psychol.*, No. 29, 1913.

partial detail in both sign and signified that is effective. The part of the one functions for the whole of the other. And contiguity is another part-whole relation. It is apparently a more remote or difficult form, only to be utilized at a higher level of intelligence. Is this perhaps why the idiot is limited to mimetic gesture and does not acquire speech, and why the imbecile is limited to spoken language?

The Problem of Identity

We cannot at this time consider in detail another difficulty in connection with our whole account of meaning, viz. the use of such terms as 'the same response.' This involves the whole logical problem of identity, which in another connection may well be more carefully exploited. Briefly this problem must be approached not through the way of 'universals' but by the aid of the doctrine of 'classes.' For our present purpose such expressions as 'the same event,' the 'same detail,' the 'same response' can more accurately be rendered ' a detail, event, or response belonging to the same class,' or even 'details, events, or responses indistinguishable from others for a given purpose.'

In the meaningful sequence, the reaction or consequent is of course not precisely identical with an earlier one, even aside from the logical difficulty. The fact is merely that no difference is discernible from the point of view of the given or particular situation, purpose, task, or instruction. Thus in experiments on discrimination, reliance on secondary details or criteria may not produce reactions equivalent in all respects to those based on primary comparisons. But for the purpose of the experiment, that is, for the purpose of revealing thresholds, it may lead to the same or equivalent verdicts, identical verbal responses, and so on. Similarly the reaction to a thought burglar is not in all details indiscernible from that to an actual one, it may be indiscernible only in its autonomic aspects or perhaps only in its verbal associative efficacy.

Even in the neuroses, where the redintegrative mechanism is so conspicuously illustrated, the hysteric symptom is

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perhaps descriptively incomplete, as compared with the original reaction to the complete event. But both reactions belong to the same class, are intelligibly characterized by the same general names, lead to equivalent types of incapacity, and so on. These minor problems, that of the nature of confidence, that of the genesis of meaning, that of the character of identity, and that of the actual incompleteness of the response to partial details, all have a systematic interest. But their final disposition has no specific relation to the general account of the mechanism of meaning and the nature of thought.

STUDIES OF CEREBRAL FUNCTION IN LEARNING VI

THE THEORY THAT SYNAPTIC RESISTANCE IS REDUCED BY THE PASSAGE OF THE NERVE IMPULSE[1]

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Among the many unsubstantiated beliefs concerning the physiology of the learning process none is more widely prevalent than the doctrine that the passage of a neural impulse through the synapse somehow reduces synaptic resistance and leads to the fixation of a new habit. All theories which are based upon frequency of repetition imply that in learning there is a preliminary penetration of resistant neural paths by irradiation of propagated disturbances and a subsequent lessening of the resistance by repeated use of the new paths. Various elaborate theories concerning the mechanism of this change in resistance have been advanced, ranging from the chemical absurdities of Robertson (1) to the recent revival of the theory of dendritic growth by Kappers (2), but no direct evidence for changes in synaptic resistance has ever been obtained. The hypothesis is not based upon neurological data but is merely a restatement of the observed fact that increased efficiency follows repeated performance.

On the assumption that spinal reflexes represent the basic mechanism of all neural activity the hypothesis has some justification, being simple and in accord with the more apparent facts. It has led to important experimental studies and has furnished a simple pedagogical formula. But the evidence is far from convincing that the acquisition of a simple function is a gradual process or one dependent upon the passage of nerve impulses. All experiments must deal with complex functions involving the successive acquisition of many elementary connections. Familiar learning curves are obviously an expression of these successive integrations

[1] No. V. of this series appeared in *Arch. Neurol. and Psychiat.* 1924.

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and we have no knowledge of the conditions prevailing in formation of a new simple neural integration. The instantaneous character of simpler associations in man, the 'all or nothing' law which governs the appearance of some conditioned reflexes,[1] and the like suggest that in these cases a single performance serves to fix the habit. If this were the case for every simple reintegration within the nervous system we should still get the appearance of gradual improvement through practice, because of the successive formation of many such simple associations or the successive blocking of interfering integrations such as seems to take place in the perfecting of the conditioned reflex.

The fact of gradual improvement in complex functions cannot therefore be taken as evidence for a *gradual* wearing down of synaptic resistance by repeated passages of neural impulses and the hypothesis must still be considered as open to question. In recent experiments upon other phases of the neurology of learning, I have made incidental observations of some phenomena which seem altogether incompatible with this theory of the wearing down of synaptic resistance and which indicate that new conditioned reflex paths may be established under conditions where the passage of significant neural impulses over the arcs in question is precluded during the whole course of learning. The experiments deal with both centripetal and centrifugal paths, in both of which it has been possible to block the peripheral neurons during training and to observe their later functioning in the performance of the habitual acts.

Conditioning of Afferent Paths which were Non-Functional during Practice

In tests of the mutual relationships of the striate areas of the cerebral cortex of the albino rat I effectually blindfolded

[1] It is characteristic that the conditioned reflex is not built up gradually, but is fully integrated when it first appears. Improvement can be expressed only in terms of the proportion of times when the associated stimulus succeeds or fails to elicit it. It is at first easily inhibited. With practice the inhibition becomes more difficult, but there is some evidence for the belief that this is due to the building up of specific resistances to inhibiting agents rather than to a simple increase in the excitability of the associated reaction.

the left eye of an animal with a velvet-lined wire and adhesive tape mask. The blindfold remained in place for a month during which the animal was trained in a Yerkes discrimination box to avoid the brighter of two lights. When discrimination was perfect (no error in 30 trials) the blindfold was transferred to the right eye. When the animal became adapted to the new adjustment his discrimination with the left eye was tested. He showed perfect discrimination with this eye which had not been used during the formation of the habit.

This result is no more than would be expected when we recall the facility with which we ourselves recognize an object with either eye when it has previously been seen with one eye alone (the common experience of the microscopist who views his field alternately with either eye). Yet this obvious fact has never been brought into relation to learning theory. Neural fibers come from the two retinæ and somewhere impinge upon a final common path. In the above experiment fibers from the right eye are integrated with the effector mechanisms of the avoiding reaction during the course of training, in which they have been subjected to retinal excitation. But the neurons of the left optic tract prove to be equally well integrated with the avoiding reaction, although that eye was not subject to photic stimulation during training.

It is not sufficient to say that this result is explained by the fact that fibers from corresponding points of the retinæ reach the same central ganglion cells. The corresponding fibers do not anastomose and there is no evidence that they have synapses in common. The wearing down of resistance in one afferent tract could not therefore affect the other. It is possible that the corresponding points activate the same central ganglion cells and that the reintegrations take place between these cells and lower motor neurons. But the following facts make this supposition rather questionable. Destruction of one eye and the contralateral cerebral visual area in the rat does not in the least affect visual discrimination. Destruction of one eye and the homolateral visual area reduces accuracy of discrimination. If the cortex contained

ganglia equally integrated with both retinæ these operations should produce like effects by destroying the final common path. Since they do not, this hypothetical final common path must lie at a subcortical centrifugal level. (The data on hemianopsia in man also indicate that the final common path, except for pupillary reflexes, is not established at a precortical level.) The impulses to habitual discrimination must therefore pass through the cortex, since the destruction of both striate areas abolishes visual habits, before they reach such common ganglia and hence the destruction of the striate areas should abolish the functional identity of impulses from the two eyes.

I have repeated the above blindfold experiment with an animal after destruction of the visual area of both hemispheres (occipital third of the cortex). The blindfold was applied to the left eye immediately after the brain operation, so that there was no possibility of the formation of new common associations through the simultaneous use of the two eyes. The results of the test with this animal were the same as with the normal one; effective performance of the habit with the eye which had been blindfolded during training was obtained.

These facts seem to exclude the theory of a simple connection of corresponding points in the two retinæ with common ganglion cells and reintegration through the passage of impulses over this final common path. As an alternative, the drainage theory might be appealed to here; the hypothesis that the excitation of a neuron exerts a suction upon all the synapses of that neuron (3), but recent work on the character of the propagated disturbance in the axon has most thoroughly exploded the doctrine of nervous energy or neurin. Moreover, the same phenomenon seems evident in recognition of tactile stimuli and no one would claim that all cutaneous afferent fibers have synapses in common or that the excitation of one final common path drains energy from all afferent tactile fibers.

It seems, then, that the theory of wearing down of synaptic resistances is inapplicable to this case of learning and that we

must seek for some other principle to account for the altered conductivity of the neuron system.

The Utilization of Efferent Paths which were Non-Functional during Learning

More striking data with the same implications have come from studies of the precentral gyrus in monkeys. These have been reported in detail (4) and a single illustration will serve for the present thesis. The right precentral gyrus was destroyed by cauterization in a cebus monkey. A severe paralysis of the left arm and leg followed. The animal was then trained to open a variety of latch boxes with his right hand. During the training there was some recovery from the paralysis but the left arm and hand were used only as a stiff prop to support the body during the manipulations with the right hand and at no time during training did the animal grasp at the latches with his left hand. When the habits were fixed the left precentral gyrus was destroyed, with a resultant paralysis of the trained right hand. The animal was kept without further training until the paralysis of the right hand had so far recoverd as to seem to permit of manipulation of the latches again. His ability to open the boxes was then tested. In the meantime he had acquired facility in the use of his left hand and the right was now by preference used only as a prop.

When confronted with the problem boxes he fumbled clumsily at the catches of each during a few trials with his right hand, then attacked the fastenings with his left hand and released them *without random movements* and almost as quickly as he had formerly done with his right hand after protracted training. There was almost perfect transfer of the habit to the hand which had been paralyzed during training.

Here, as in the centripetal end of the arc, we have evidence of the utilization of neural paths in the performance of a learned reaction which were not activated during the course of learning. In this case the drainage theory is definitely ruled out. Irradiation of impulses to symmetrically placed

spinal neurons might account for the results but I have records of other cases where the head or leg was substituted for the arm rendered useless by operation and where, consequently, irradiation cannot explain the transfer of the habit to the unused organ.

It seems certain, then, that we have here two types of habit formation which cannot be explained by any wearing down of synaptic resistance through the passage of nerve impulses. The behavior is of a complex character, approximating what is termed ideational behavior in man. Placing it in this category, however, does not advance our problem, which is to understand the physiology of reintegration. Most familiar cases of learning, even the so-called conditioned reflex, approach this order of complexity so that these cannot be looked upon as exceptional cases but rather tend to discredit the theory as applied to any learning.

An alternative theory is not possible in the present state of the science of neurophysiology but there are suggestions in recent experimental work that such a theory must develop in a quite different direction from that which it has thus far taken. Spinal reflexes as they are usually described are such simple diagramatic affairs that they have captured our imagination to the exclusion of other neurological phenomena and have been taken as the pattern of all nervous activity. As conditioned reflexes they have been expanded to embrace all nervous activity, until the telephone system has come to be looked upon as an adequate analogy for all central nervous function. But the phenomena of equipotentiality of function of cerebral areas (**5**), of vicarious function without definite localization (**6**) of mass action of central ganglia (**7**) of temporal variation in function (**8**), and the accumulating mass of evidence which indicates that in the intact organism every reaction is an expression of the total activity of the central nervous system, all are difficult to harmonize with a system of anatomically restricted reflex paths defined by varying degrees of synaptic resistance.

Work upon the 'all or nothing' character of conduction and the refractory period of nerve suggests that the rate at

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which the neuron may transmit successive impulses is at least as important in determining the direction of conduction as the degree of synaptic resistance. The theories of inhibition of Verworn (**9**) and Lucas (**10**) involve the conception of critical frequencies of impulses for each neuron. If this should be verified for the central nervous system we may have to seek for changes in the refractory period rather than at the synapse as the basis of the learning process and for changes in the periodicity of discharge within a syncytium rather than for anatomically defined conduction paths to account for new integrations.

The observations recorded above are more in accord with such an hypothesis than with the current one based upon synaptic resistance, but detailed speculation in this field is futile so long as experimental work is unavailable. I am concerned here only to point out the inadequacy of present learning theory and to emphasize the importance of neurological investigation for the correct interpretation of even such psychological findings as the 'Law of Frequency' in learning.

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THE FORMATION OF ASSOCIATIONS

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That some symbolic picture of the mechanism of the formation of associations is as desirable as a theory of color vision will be admitted by most. And the attitude taken towards the two types of theory should be identical. They are to be considered as attempts to make more explicit what little we know about the action of the nervous system. Granted that we do not know much about the more central neural functioning, are we any better informed concerning the nervous parts of the sense organs?

The writer has felt a growing need for a visual aid not only in teaching the psychology of association but also for his own better understanding of the subject. As McDougall[1] says, "If we can find a satisfactory solution to this problem, this solution in conjunction with the law of neural habit will enable us to explain the fundamentally important process of neural association by temporal contiguity. If no solution can be found, physiological psychology is bankrupt."

Yet an inspection of the more popular text-books in psychology show that very few authors have attempted an explanation of the formation of associations. Most writers start in the middle of the problem with the uses of already formed associations and either tacitly admit that their formation is a problem of too great difficulty for them or that it is incapable of solution.

However, the writer believes that greater advance can be made by trial and error than by evasion and offers the following hypothesis as an intellectual punching bag.

Let it be understood that it is only an hypothesis, the value of which must be determined by its capacity to explain the known facts and at the same time not to explain too much. Let it be further kept in mind that the argument

[1] 'Physiological Psychology,' p. 126.

throughout is of a geometric-mechanical nature and is supposed to give a general picture rather than intimate details of neural functioning.

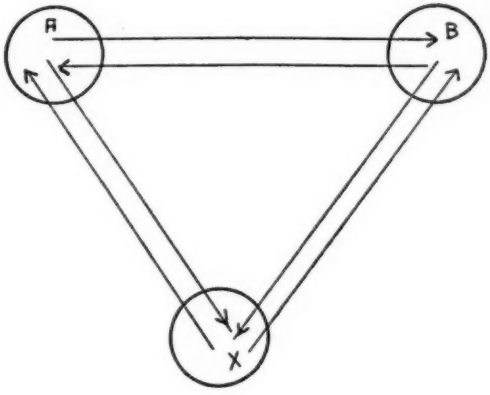

FIG. 1

In spite of differences of phraseology, the law of association as given in the texts may be interpreted to read; "If two experiences *A* and *B* appear in consciousness together or in close succession, then subsequently when *A* reappears in consciousness, *B* tends to follow it." Of the two clauses in this formulation, the first refers to the formation of associations, the second to the use of associations in recall. The second has received intensive development in the literature; the first has not.

Analysis of the first clause reveals two implications: first, that the unit of the association process is two experiences; second, that their 'togetherness' in consciousness is a condition necessary for the formation of the association. The importance of the time element is further emphasized by the experiments on remote association.

When we raise the question of what is associated, three possibilities present themselves—objects, experiences, and cortical regions. Since objects and their relations can be known only through experience, the first possibility psychologically reduces to the second. The second in turn must be

abandoned because an association represents a relatively permanent bond, whereas an experience is transient. But the third contender, cortical regions, is of sufficient permanence to be considered. Its claims are further abetted by the current psychological belief in some sort of relation between consciousness and nervous activity. We shall follow convention and say that association is a condition favorable to the spreading of nervous impulses from one brain region to another, the respective regions being functionally related to experiences. The convenient formulæ, 'openness of pathways' and 'pathways of low resistance' will be used to describe such a favorable condition. No matter whether we belong to the radical or conservative element with regard to the cortical localization of function, this scheme is general enough to admit of whatever picture is demanded.

By general agreement, 'open pathways' are explained in terms of synapses. But regarding laws of action of synapses the text-books are evasive. However, by reading between the lines as well as by taking into account direct statements, four general laws of the synapse which seem to have a majority vote may be given. They are:

1. The synapse offers resistance to the passage of the nerve current.
2. The synapse allows transmission in only one direction.
3. Use decreases resistance.
4. Disuse increases resistance.

Our problem then reduces to explaining how and why two nervous regions, *A* and *B* active together or in immediate succession tend to become connected by pathways of low resistance, while *A* and *X*, the latter being relatively inactive, do not become similarly connected.

Three cortical regions, *A*, *B*, and *X* will be assumed. *A* and *B* are to be considered as stimulated perceptually, *X* as unstimulated. It is commonly admitted that these regions are nervously interconnected. The existence of pathways need not consequently be accounted for; changes in relative resistance in pathways are what demand explanation. And the only law of synaptic action unanimously held which can be

applied here is the third given above, 'use decreases resistance.' That the original formation of associations cannot be explained by this law alone was pointed out by McDougall [1] many years ago. It can explain the 'stamping in' of associations and their use in recall, but not their formation.

McDougall, because of this fact, advances a second principle not included in the list of four laws given above and called by him 'the law of attraction of the impulse.' Taken in conjunction with the law of neural habit it is used by him to account for the formation of associations and this it does in a satisfactory manner. But because it cannot be used to explain certain peculiarities of facilitation and inhibition, among other things, it must either be abandoned or modified.

The hypothesis to be advocated in this paper is frankly a modification and an extension of McDougall's drainage theory. McDougall's theory was unfortunate in two respects. First, in giving a hydrostatic illustration, for many remember the physics and forget the neurological concept. Secondly, it was unfortunate in using a single track connection between cortical regions, for this has been the principal reason for its inadequacy. By common consent, the sensory regions of the cortex are not only connected but *inter*connected. Consequently there can be no serious objections to regarding the cortical regions as interconnected by a 'double track' system. This assumption involves also certain changes in the picture of the cortical areas involved, for, since the synapse allows passage of the nerve impulse in only one direction, we must extend our brain region to include groups of neurons which can carry energy from region *B* back to *A*.

Our first assumption is then of three complex cortical regions, *A*, *B*, and *X*, interconnected by double track pathways as follows: *AB*, *BA*, *AX*, *XS*, *BX*, *XB*.

Our second assumption is that when a brain region *A* is stimulated, it tends to radiate energy over all possible pathways, in this case *AB* and *AX*. Furthermore, the energy thus derived from *A* by *B* is radiated towards *X* and also towards *A*. The case is similar for *X*. This radiation may

[1] McDougall, 'Physiological Psychology,' pp. 124–139.

be thought of as lasting as long as *A* continues to be stimulated or until possibly fatigue raises the resistance of the synapses encountered. When *B* is stimulated in its turn, nothing is added to the picture except more energy which can circulate through the various regions. There is no reason, if radiation be the only factor, for assuming a greater interchange of energy between *A* and *B* than between *A* and *X* or *B* and *X*. In other words, radiation alone, no matter how important a factor it may be in the general scheme of neural mechanism, is inadequate to explain the formation of associations.

In general, it is held that the radiation is proportional to the total nerve energy in the region in question and that the amount of radiation over two different pathways is inversely proportional to the resistance of the synapses encountered.

Our third assumption is similar to McDougall's and is expressed by the term *attraction*.[1] By this word is meant a condition whereby activity in a given region automatically decreases resistance in pathways leading towards the active region. What the total effect will be is a matter of relative resistance rather than absolute.

Though not usually expressed in this way, the concept of attraction is by no means new in psychology. James[2] for

[1] It is frankly admitted that 'attraction' is an unsatisfactory word to use as descriptive of the condition meant, for at first thought it appears to mean a sort of a suction similar to that exerted by a vacuum, or possibly a magnetic attraction. This is apparently the meaning employed by Woodworth ('Psychology,' pages 401–402) in his discussion of the conditioned reflex. He says: "The effective stimulus determines what response shall be made, and the other stimulus finds an outlet into that response, being as it seems, *attracted* towards the activated response, *sucked into it*." Needless to say, the term is employed in a very different sense in this paper. What I mean to convey by the term attraction is a *condition in the synapses*, specifically a *decreased resistance*, which is the outcome of the action of the cell bodies to which the dendrites involved in the synapse belong. In spite of the difficulties, the word *attraction* is retained for the following reasons: It is McDougall's word, and in a modification of his theory may well be retained. Secondly, it is desirable to have a word which may be contrasted with radiation. Third, I have been unable to find a better word to substitute for it. 'Facilitation' is already preëmpted and 'expedition' in the sense of making easier through the removal of obstacles and obstructions is awkward and at the same time has a somewhat different conventional meaning. However, any one is at perfect liberty to employ the term 'expedition' if he quibbles at 'attraction.' The essential thing is the meaning.

[2] James, 'Psychology,' Vol. I, p. 567.

example, says: "The amount of activity at any given point in the brain cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate . . . (3) to the absence of any rival point functionally disconnected with the first point, into which the discharges might be diverted."

Pillsbury,[1] speaking of the idea as a condition of attention, says: "When a question is asked, the nervous impulse spreads from the cells excited by the question to others that have previously been excited in the same connection. An object appealing to any one of these cells will find entrance to consciousness made easy for it. Part of the work has already been done." How can this be interpreted except as a nameless appeal to the principle of attraction?

Titchener,[2] in his discussion of congruity as a determinant of attention, speaks as follows: "As for the effect of congruity with consciousness, it is clear that the more nearly an incoming excitation coincides with an excitation already in progress, the more easily will it make its way within the central nervous system, and the more dominant it will become." I believe that we do him no injustice if we take the responsibility of reading the principle of attraction into his sentence.

Not only is some such principle as attraction necessary to explain the subjective conditions of attention, but it is equally indespensible in accounting for the efficacy of the purpose in reasoning, the intention in volition, in fact, for control of the thought and action processes wherever encountered. The writer would go so far as to say that he can see no other explanation for control. While it may be granted that in some instances summation of energy derived from the stimulation of the sense organs and from cortical action already going on in a given region may be sufficient to explain certain adjustments, it is inadequate to explain attention given to a faint stimulus while the individual is exposed to much more intensive ones. The general scheme may easily

[1] Pillsbury, 'Essentials of Psychology,' p. 124.

[2] Titchener, 'A Text-Book of Psychology,' Vol. I, p. 271.

be understood from the accompanying diagram, 2. *A* is a sensory neuron connecting with two different pathways, *BC* and *ED*. Suppose that the *BC* pathway has been made more pervious due to primacy, recency, frequency, and in-

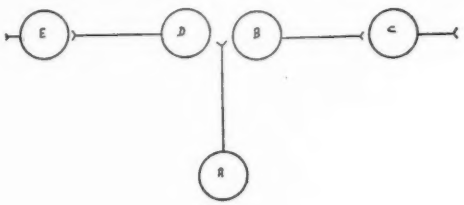

FIG. 2

tensity. Then when *A* is stimulated, the energy would go through *B* and *C*. But again, if *A* be stimulated when *E*, the nervous correlate of the idea, the purpose, or the intention is active, the picture changes. By attraction, the relative resistance of the synapses between *A* and *D* automatically decreases, possibly even to the extent of deflecting the current through the *DE* pathway. It is absolutely certain that neural habit alone will never explain the situation described above, and attraction seems to be the simplest and at the same time the most orthodox assumption that will.

Attraction may well be considered a result of radiation and consequently must be pictured as less potent. Otherwise the radiating region could never come to rest until much of the nerve energy in the cortex was exhausted. It may also be held that perseveration is a function of attraction, as well as of inertia. Three other statements should be made concerning attraction: first, it varies directly with the amount of radiation; second, the amount attracted varies directly with the amount of energy in the region attracted from; third, it varies inversely with the attraction exerted by other regions.

Having added a third supposition to the hypothesis, the next step is to determine whether it can explain, not only the formation of associations, but also certain of their peculiarities as revealed by recall.

A. Formation of Associations

When region *A*, Fig. 1, is stimulated, it radiates energy over pathways *AB* and *AX* into regions *B* and *X* respectively. At the same time attraction is exerted on *B* and *X*. But since there is little or nothing there except the energy received from *A*, and since the amount attracted is proportional to the amount of energy that can be drawn upon, the result of the attraction is practically nil. But while *A* is supraliminally active, suppose *B* is stimulated. Radiation tendencies occur over pathways *BA* and *BX*, attraction tendencies over pathways *AB* and *XB*. *X* for the reasons already given is comparatively inactive and whatever energy may have been in it is attracted to *A* and *B*. But a reciprocal interchange of energy does take place between *A* and *B*. By radiation from *A* and attraction from *B*, the *AB* pathway is traversed by the energy in *A*; by radiation from *B* and attraction from *A*, the *BA* pathway is traversed by the energy in *B*. *X* fades from the picture because of its functional impotence. Since use decreases resistance of synapses thereby making pervious pathways, we have accounted for a pathway of low resistance between regions *A* and *B* and have also shown why pathways *AX* and *BX* do not have their resistance reduced under the conditions stipulated. In other words, we have accounted for the formation of associations by contiguity and succession.

It remains to show whether the theory outlined above will explain the peculiarities of the formation of associations as revealed by recall, recognition or relearning.

B. Explanation of Phenomena

1. *The Relation between Attention and Association*

That the strongest association tends to be formed between experiences which are attended to in immediate succession has been for years an accepted generalization. There is good reason to believe, as suggested in Ladd and Woodworth [1] that "degrees of consciousness may probably be taken as indicative of degrees of brain activity. The field of atten-

[1] Ladd and Woodworth, 'Elements of Physiological Psychology,' p. 609.

tion may therefore be taken as an index of the field of greatest brain activity." This point of view enables us to explain very nicely the point in question, in fact, it has been explained. Radiation and attraction will be greatest between those regions simultaneously most active and hence the association *AB* would be most favored. But our hypothesis would permit, though not necessitate, the formation of a weaker association between regions *A* and *X* and *B* and *X*. The actual result would depend upon the relative degree of activity of the cortical regions involved and also upon the momentary resistance offered by their interconnecting pathways.

2. *Inhibition and Facilitation*

A second topic which must be accounted for in any hypothesis to explain the formation of associations is the situation discussed under the terms inhibition and facilitation. Whether these two terms are descriptive of a positive and a negative manifestation of the same tendency, or whether both are to be considered as positive, is a debated point. In either case, inhibition may be referred to as a blocking of neural pathways, which may be supposed to result from lack of use; from fatigue, or from the change in relative resistance of synapses because of attraction which deflects the nerve impulse in some other direction. Facilitation, similarly, may be explained either by use or by attraction. It is probable in both cases that attraction is the essential element involved when the words are used in their common psychological meaning. The whole principle has already been described in Fig. 2, in connection with the discussion of attraction as an assumption. Specific cases will be considered more in detail later.

3. *Backward and Forward Association*

One of the objections to the McDougall drainage theory was its inability to explain why the forward association is so generally stronger than the backward. Our hypothesis explains this situation easily. When *A* (Fig. 1), is stimulated to its greatest degree as it is when attention is given to experience *A*, radiation and attraction are at their strongest. By the time *B* is in turn maximally active because of the

shift of attention from *A* to *B*, *A* is less active and consequently does not radiate or attract so strongly. *A* in the weakened condition can exert less attraction on *B* than *B*, fully active, does on *A*. Furthermore, we must suppose at least one more synapse in the *BA* pathway than in the *AB*, the one between the receptive part of *B* and the part which transmits back to *A*. This extra synapse would lengthen the time of the backward association and part of the nerve energy radiating from *B* would be used up in overcoming resistance. The result is that more energy goes over the *AB* pathway and less over the *BA*, the condition necessary for a forward association stronger than the backward. Under normal conditions it also happens that experience *B* is followed in turn by experience *C*. Region *C* then tends to attract from *B* and consequently the radiation from *B* to *A* is to some extent at least inhibited. Where *C* is a repetition of *A*, as sometimes happens in experiments on association and memory, the result may be, as was shown by Wohlgemuth, forward and backward associations of equal strength, or a backward association stronger than the forward.

4. *Remote Associations*

In Meyers's [1] discussion of remote association, the following table is given:

Saving in relearning 16 syllable series	33%
Saving with alternate syllables omitted	10.8
" " 2 consecutive " "	7.0
" " 3 " " "	5.8
" " 7 " " "	3.3

This shows that the strongest association is between contiguous members of the series, *AB*, *BC*, *CD*, etc. It shows also that there is a less strong association between *AC*, *BD*, and so on.

This phenemonon is explained by the two arguments already used in the preceding section. The maximum association exists between contiguous members of a series because they are maximally active in immediate succession and consequently the results of radiation and attraction are

[1] Meyers, 'Text-Book of Experimental Psychology,' 1909, p. 165.

at their strongest. By the time *C* is attended to, the radiation from *A* is already decreased because of lessened activity in *A*. A part of the energy radiated from *A* goes to *B* and we may suppose, as soon as *C* begins to attract, to *C* also. The energy consequently is divided between two pathways. The attracting effect of *C* on *A* is lessened as soon *D* becomes active, and another division of energy occurs. The more widely separated in point of time the stimulation of the two regions the less effective is the associative bond between them.[1]

5. *Associative Inhibition*

Associative inhibition reduces to forming the associations *AB* and *AC* almost simultaneously. When this has been attempted, the result has been a longer learning time than would have been necessary for the separate and complete formation of the two associations independently. Explanation demands that we show two things: first, that the paths *AB*, *BA*, *AC*, *CA* are traversed by more nerve energy than pathways *BC* and *CB*; second, that pathways *AB* and *BA* are traversed by less energy under this condition than when the simple *AB* association is being formed. The first point is demonstrated by the same argument as that used to explain the remote association. The time interval separating the appearance of *B* and *C* in consciousness is greater than is the case with either *AB* or *AC*. Consequently, the *BC* association, using the pathways *BC* and *CB*, is the weakest of all; if the time interval is great enough no associative tendency will be formed.

The second point is almost equally obvious. For if *AB* is followed immediately by *AC* the attraction exerted by *B* on *A* loses force automatically when *C* becomes active and *C* is robbed immediately afterwards by the renewed activity of B.

6. *The Effect of Rhythm*

Rhythm is commonly agreed to be an aid in learning or forming associations. The strongest connections are made

[1] The experiments of Froeberg on the effect of the time interval on association do not invalidate this statement, for it was possible to repeat the stimulus verbally and continuously during the interval before the second stimulus appeared.

between members of the rhythmic group. Is there any fact involved in rhythm itself which will help in explaining this phenomenon? Apparently, yes, for rhythm differs from periodicity in at least two important particulars. First, a stress or accent is present, either objectively or subjectively, and the neurological explanation is quite probably relatively more intensive activity in the brain region involved. This greater intensity of action in turn suggests greater radiation and attraction between this region and others. In the second place, the separate elements in the 'foot' come closer together either actually or apparently than do the contiguous elements of different feet. The result is that the members of one rhythmic unit have a longer time to coalesce by mutual interchange of energy due to radiation and attraction than do contiguous elements in different units.

7. *Fluctuation of Attention*

It has been asserted that a drainage theory of association cannot explain why, in the case of nonsense syllables, for example, the fluctuation of attention to the second leaves the first still in consciousness, while in the case of illusions of reversible perspective the stairway disappears from consciousness when the cornice appears. Apparently we are asked to explain in terms of a drainage theory why so diverse conscious results may come about in response to so similar situations. But the answer is very simple; the situations are not at all similar. In the first case, we have two different stimuli, in the second, two different interpretations of the same complex stimulus. The simultaneous awareness of two nonsense syllables is explained by the argument used in connection with Fig. 1; the inhibition of the staircase by the cornice is accounted for by the discussion used in connection with Fig. 2. If the *BC* regions are supposed to be active in the staircase experience and the *DE* in the cornice, fatigue of synapses through use would account easily enough for the change in their relative resistance.

8. *Association and Involuntary Attention*

If the simultaneous activity of two brain regions be the necessary condition for the formation of associations, why is it that the last idea in an interrupted train of thought or observation is not associated with the interrupting stimuli. Why is the ringing of the telephone bell not associated with the previous topic of conversation? Two sorts of answer are possible. One is an appeal to the secondary laws of intensity and frequency. Sometimes such associations are made when the two stimuli are intense enough. But usually the element of repetition is lacking. Diversity is the more frequent condition, the sound of the telephone bell following now one idea and now another. The second answer is an appeal to the more or less complete organization of knowledge into systems, known under a variety of terms which may be illustrated by apperceptive masses and concepts. Such an organization implies a corresponding series of systems of functionally associated neurons, the various parts of which are intimately interconnected, but one system being less intimately connected with another. The topic of thought or conversation belongs to one series and calls out its own system of responses, the sound of the bell belongs to another class or system associated with its own responses. Obedience to the summons of the bell changes the environment, deflects the maximum of cortical energy from one region to another and provides a set of stimuli unfavorable to the previous line of thought. Its functional cortical region is robbed of its energy by the areas involved in the telephone experience. Diversity and lack of repetition do the rest.

9. *Retroactive Inhibition*

Retroactive inhibition, the effect upon retention of mental activity immediately following a period of learning, has been found to be operative under some conditions, but not under others. The evidence is so contradictory that speculation is more or less idle. A frequent explanation has been that the mental activity subsequent to learning checks or prevents perseveration, an assumption that agrees very nicely with

the principle of attraction. But, say the opponents, if it works in one situation, it ought to work in all. It does not work for all, therefore the argument is unsound. But they overlook the point mentioned in the preceding paragraph. It is only logical to expect that the effects of radiation and attraction shall be greater between the better associated regions and less between those having poorer connections.

The result is the expectancy that the greater the dissimilarity between the materials used in learning and in subsequent work, the less will be the interference, for the less likely are the brain regions to be intimately associated. Similarity of the two materials should give greater inhibition. We should also expect that an increasing time interval between learning and work would be accompanied by decreasing retroaction. These are exactly the conditions found by Skaggs.[1]

10. *Distributed Repetitions*

The greater efficiency of distributed repetitions is usually pictured as being due to a condition the reverse of retroactive inhibition. If the successive stimulation of two brain regions results in reciprocal radiation and attraction, the addition of a third, fourth, fifth active brain region results in a steady decrease of energy in those active in the first part of the series because of radiation to and attraction from the subsequent ones, as was shown in connection with remote associations. The result is a lessening of the total amount of energy exchanged between *A* and *B* and consequently a poorer association. It is only when the other regions are relatively inactive that the strongest *AB* association is formed.

I turn now to a consideration of the article by Shepard and Fogelsonger[2] in which direct challenge is offered to the drainage theory in the following words: "If this analysis is true, we have an inhibition which it would be difficult or impossible to bring under the concept of drainage. No connection or path has been formed which would rival that already 'sub-excited' between the representation of the stimulus and the reaction. . . . We find evidence of a definite

[1] E. B. Skagg's thesis, unpublished; to appear in PSYCHOL. MONOG.

[2] PSYCHOL. REV., 1913, pp. 290–311.

inhibition which cannot be brought under the ordinary interpretation of generative and effectual inhibition and which cannot be explained neurologically as a division of energy, or drainage."

In their investigation of inhibition, these men used 14 different arrangements of nonsense syllables, as will be described below. Six subjects took part in the experiment though not all six were used in all parts of the test. In fact, in two parts out of the fourteen, only one subject was employed. Records of both time and accuracy of recall were kept, making possible two independent measurements of inhibitive tendencies. If, as pure theory demands, increase in time of recall is accompanied by decreased success in recall, the correlation between time and success should be − 1.00. As a matter of fact, the obtained correlation is − .52, a figure which leaves us in some doubt concerning the proper measure of inhibition. However, additional light may be obtained by consideration of other factors.

The entire group of 14 arrangements of syllables can be divided into 5 sub-groups in terms of the number of syllables presented to be associated or learned. Average recall times for the different sub-groups are as follows:

Number of Syllables to be Learned	Relative Time of Recall
2	100
3	167
4	250
5	305
6	425

The time of recall, then, varies almost directly with the number of syllables in the learning material. Consequently, in the present investigation of Shepard and Fogelsonger, recall seems to be the significant measure of inhibition, though time differences of recall when the same number of syllables to be learned are compared, may be of some value.

Concerning the effect upon recall resulting from simultaneous or successive appearance of test syllables, nothing final emerges from the results, for in some cases one is favored, in others the other. The averages for the two are about the same.

The fourteen types of situation investigated by Shepard and Fogelsonger are shown in the form below. Letters are used to stand for syllables, relative time and relative accuracy of recall are given.

Learned	Test	Relative Time	Relative Recall
a-b	*a*	100	100
(c-d)(e-d)	*c-e*	147	103
c-d-e	*c-d*	140	87
c/d-e	*c/d*	143	96
(f-g)(h-g)	*f/h*	236	80
m-n	*m-x*	180	63
m-n	*m/x*	259	55
d-e	*x-d*	207	86
(f/g-h)(i/j-h)	*f/j*	230	92
(f-g-h)(i-j-h)	*f-j*	379	100
(i-j)(k-i)	*i-k*	252	82
(i-k)(k-l)	*i/k*	248	95
(k-l-m)(n-o-p)	*k-o*	424	42
a-b-c	*a-b*	69	114

Parentheses indicate that the syllables contained in each were given at different times. A hyphen shows successive presentation, the / sign simultaneous presentation.

Inspection of the arrangements of materials employed in testing shows that they cannot be used, as a whole, against the proposed modification of the McDougall drainage theory. The experimental conditions were such as to compel inhibition. In the one case (*a-b-c*) where facilitation apparently developed, this result is apparent rather than real, for at the beginning of the experiments the subjects were untrained in memorizing nonsense syllables and improvement is the customary result with practise. Furthermore, when these results are combined with those contained in the third line of the table, evidence of facilitation disappears. The reason why we may expect to find evidences of inhibition so generally is because their test material consisted of two syllables.

Our theory specifically states that when two brain regions are simultaneously active in attention, as they are with the test material used, an exchange of energy between them takes place, thus causing a division of energy, diverting some of it from the pathways leading to the region involved in recall. To disprove the theory they must demonstrate by experi-

mental evidence the absence of any associative tendency between the test syllables after the test. When the test syllables were a part of the material learned in any one series, it is extremely probable that an association tendency would be formed. When the test syllables were parts of two different series and observed at different times, their presence, either simultaneously or successively, is adequate to cause an associative tendency, even though no previous connection due to the learning existed. Consequently, these experiments instead of disproving a drainage theory offer much evidence in its favor.

And what is true of the whole is true of the parts when we come to consider them in detail. In fact, but one situation needs discussion, for the rest appear to the writer to be too obvious. If we compare the following situations in the material to be learned, some speculation may be indulged in. Results for the same subjects are given in the same row:

	a-b-c		*c/d-c*		*(c-d)(e-d)*	
	Time	Recall	Time	Recall	Time	Recall
Fc....	131	87	167	98	167	95
P.....	67	90	200	93	260	93
W....	59	104	93	77	442	90
A....	82	149	57	120	296	105
	339	430	517	388	1165	383
	85	108	129	97	291	96

The first thing that strikes our notice is the facilitation both in time and in recall with the *a-b-c* learning material. The test material was *a-b* and the time was measured from the appearance of *b*. Since the presentation of *a* and *b* in testing was separated by an interval of one second, we can roughly approximate the association time from the appearance of *a* by adding 1000 sigma to each of the recall times. When this is done it makes the relative time 133 instead of 85. However, if timing is begun when *b* comes to view or if *a* and *b* are presented simultaneously, we may expect the recall time to be shorter for the following reason. In the complex assocation we find that not only are the *ab* and *bc*

associations formed, but the *ac* as well. Now if the *ab* path have an associative strength of 100 percent and the *ac* of 32.4 (see remote association above), it is probable that the *bc* pathway will have less than 100 percent efficiency because of the interference of *a*. Still, the amount coming to *c* from both *a* and *b* is greater than the amount coming from *a* to *b*, and the association time ought logically to be shorter and the amount recalled somewhat higher; this is exactly the condition we find.

The *c*/*d*-*e* situation shows no definite evidence of recall inhibition, but does indicate a slight time inhibition. This *c*/*d*-*e* situation is somewhat anomolous, for if the syllables are read *c*-*d*-*e*, it reduces to the one just discussed; if they are read (*c*-*e*)(*d*-*e*) it more closely approaches the third in the table. However, with *c*/*d*-*e* material to be learned, the three syllables were in the same series. In the third case, *c*-*d* was given in one series, *e*-*d* in another. Consequently, the association pathways must have been different in the two cases. The *c*-*d*-*e*- situation has already been disposed of, and the results show that this must have been the usual method of reading. If, however, the syllables were read *c*-*e*, *d*-*e*, we are sending maximum energy over the *c*-*e* and *d*-*e* pathways, but since *c* and *d* appear together, there must be some associative connection made. In the (*c*-*d*)(*e*-*d*) material, either no *ce* association was formed, or at most a very slight one. The whole question then reduces to the following: Can the presence or absence of an associative tendency between two syllables inhibit or facilitate the arousal of a third syllable which has been associated with both of the others. In either case we would get a spread of energy between the brain regions functionally connected with the first two syllables and it is only logical to expect greater consumption of energy when much work is to be done by way of modification and overcoming of resistance. In this situation less energy is left to cross synapses leading to the third region. Now if, as has been asserted by some, the time necessary for a nerve current to cross a synapse varies directly with the intensity of the current, decreased activity should slow up the recall

time. This is exactly what happens in the (*c-d*) (*e-d*) case.

We pass now to a consideration of the sensorimotor association. Random muscular activity, the result of chance stimulation of the motor cortex, results in activity in the kinæsthetic and possible other brain regions. The condition is just that demanded for the formation of associations, the simultaneous activity of two brain regions. But one feature in the picture is different. Here we do not have a double track system of connections, for association fibers running from motor to sensory regions are not mentioned by any of the authorities consulted. In this situation we may expect to get drainage in the McDougall sense.

The complexes of this situation, represented by the conditioned reflex, transferred stimuli and the like can be accounted for in a satisfactory manner. In Watson's study of fear, for example, we find that an innate connection evidently existed between a sound region *S* and a response region *M*. When a light *L* appeared simultaneously with *S*, a condition was brought about eventually showing the existence of an association between *L* and *M*. Here we have three brain regions involved in learning, *S*, *L*, and *M*, simultaneously active in the cortex. Since pathway *S-M* is innate and since it has also been modified by experience, we would expect to find it offering little resistance to the nerve current. How then does *L* ever become a part of the complex? When *L* is active simultaneously with *S* and *M*, it tends to radiate its activity in those directions and also to attract from them. Similarly, *S* tends to attract from *L* and radiate towards it. However, since the *S-L* and *L-S* pathways are less pervious than *S-M*, less energy goes over them and the formation of the association goes on slowly. The *L-M* pathway is also formed comparatively slowly, taking from 18 to 45 repetitions or even more. But pathways are finally formed, connecting *L* with *M* so that the subsequent stimulation of *L* is adequate to arouse the response formerly connected with *S*. In fact, all we have to do is to account for the formation of the *L-M* pathway, for the *L-S* or *S-L* path may be considered as a nonessential by-product of the situation. In fact, it seems

plausible that the *L-M* pathway should be somewhat more firmly established than the *L-S*. For though there is no *M-L* connection directly made, an indirect pathway exists by way of motor neurons, kinæsthetic neurons and subsequent activity in the kinæsthetic region which may be attracted to the *S* and *L* regions. This would result is giving a temporarily continuous supply of energy to those regions rather than the waning sort demanded by the radiation-attraction principle. And this may be, in part at least, the reason why a successful movement is so likely to produce a change in the general content of consciousness.

One other problem remains to be considered, that of the principle of organization. Some assert that, in order to explain the organization of consciousness, an organizing center, the seat of a super-intelligence or even a pre-intelligence is necessary. Of course, such a concept is not demanded, for if our experiences come initially from the physical world, and if the physical world is rationally organized, frequency of stimulation would be a sufficient explanation. If contiguity be the sole condition of association, it is logical to assume that succeeding experiences should *usually* be those pertaining to the same object or with the antecedent and consequent relationship, which, because of frequency of appearance, become an essential part of cause and effect. Consequently, because of the emphasis given by frequency, there is as much organization in experience as in the observed world. When to this we add the elaborations made possible by identity, similarity, and contrast, it is easy to see how the mental can transcend the external world.

Summary

McDougall's drainage theory of association, based upon the principles of radiation and attraction of nervous energy over 'single track' paths between cortical areas has been found incapable of explaining the complex phenomena of association. If to his theory is added the single concept of 'double track' paths between cortical areas, it is much improved and can be used as a basis for explaining the facts of association and memory as given in the text-books.

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Radiation is the word used to mean the flow of nerve energy from dendrite through axon in a general sensorimotor direction. The amount of radiation depends upon the intensity of the nerve current, and the direction is controlled by the relative resistance of synapses encountered.

Attraction is a principle depending upon radiation, for when owing to radiation a nervous region becomes active, the activity in turn reduces resistance of synapses leading to the active region. The amount of attraction is proportional to, though always less than, the amount of radiation.

When two cortical regions are simultaneously active, the two forces of radiation and attraction tend to focalize the direction of nervous drainage so that the maximum discharge is between them.

The theory can be used to explain the generally accepted facts of association and memory—the relative strength of backward and forward association, the various kinds of inhibition, facilitation, remote association, and the laws of memory.

CRITICISMS OF THE LAWS OF EXERCISE AND EFFECT

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1. Introduction

The laws of exercise and effect have become a part of the psychology of many modern writers, and they have attained a prominence which we think is not entirely justified. It is our purpose in the present paper to criticize both of these laws, and attempt to show that they do not fit the facts of learning. The apparent confusion in regard to the laws of exercise and effect seems to arise partly from the assumption of such non-physical entities as mind and consciousness, and partly from a somewhat premature attempt to describe the physical 'correlates' of satisfyingness and annoyingness. The history of association psychology shows the futility of attempting to build a science on a mentalistic assumption. In contrast with the association psychology of former years, we assume in the present paper that an association is between a stimulus and a response, and not between two ideas or two external objects.

2. The Law of Exercise

In the present section, in which we attempt to criticize the law of exercise, we shall (1) state the law of use, which is a part of the law of exercise, (2) attempt to show that some other factor is always present in learning in addition to the mere exercise of a single stimulus and a single response, as postulated in the law of use, (3) criticize the common analogy of the muscle, which is also said to improve with 'exercise,' (4) attempt to show the improbability of the physical mechanism postulated for the law of use, and (5) discuss and criticize the law of disuse.

The law of exercise includes the laws of use and disuse. We shall now attempt to show that the *law of use*, which

states simply that the exercise of a function improves it, is not an accurate statement of fact.

Thorndike's Statement of the Law of Use.—In the 'Original Nature of Man,' Professor Thorndike states the law of use as follows: "To the situation, 'a modifiable connection being made by him between a situation *S* and a response *R*,' man responds originally, other things being equal, by an increase in the strength of that connection. By the strength of a connection is meant the probability that it will be made when the situation recurs. Greater probability that a connection will be made means a greater probability for the same time, or an equal probability but for a longer time. Thus, strengthening the connection between 'being asked how many six and seven are' and 'saying "thirteen,"' may mean that the probability of that response during the next six days is eight out of ten instead of seven out of ten, or that the probability is seven out of ten for sixty days instead of for forty."[1] The statement of the law of use in Professor Thorndike's 'Psychology of Learning' is substantially the same.

Woodworth's Statement of the Law of Exercise.—Professor Woodworth, in discussing the law of exercise, writes as follows: "Of one law of learning, we are perfectly sure. There is no doubt that the exercise of a reaction strengthens it, makes it more precise and more smooth-running, and gives it an advantage over alternative reactions which have not been exercised. . . . This law is sometimes called the 'law of habit,' but might better be called the 'law of improvement of a reaction through exercise,' or, more briefly, the 'law of exercise.' The law of exercise is very broad in its scope, holding good of life generally and not alone of mental life. Exercise of a muscle develops the muscle, exercise of a gland develops the gland; and, in the same way, exercise of a mental reaction strengthens the machinery used in making that reaction. Let us restate the law in terms of stimulus and response. *When a given stimulus arouses a certain response, the linkage between that stimulus and that response is improved by the exercise so obtained*, and thereafter the stimulus arouses

[1] Thorndike, E. L., 'The Original Nature of Man,' p. 171–172.

the response more surely, more promptly, more strongly than before."[1] Professor Woodworth, in a further discussion, treats the neural basis of the law of exercise: "Exercise, then, has the same general effect on neurons that it has on muscles; it causes them to grow and it probably also improves their internal condition so that they act more readily and more strongly. The growth, in the cortex, of dendrites and of the end-brushes of axons that interlace with the dendrites, must improve the synapses between one neuron and another, and thus make better conduction paths between one part of the cortex and another, and also between the cortex and the lower sensory and motor centers. The law of exercise has thus a very definite meaning when translated into neural terms. It means that the synapses between stimulus and response are so improved, when traversed by nerve currents in the making of a reaction, that nerve currents can get across them more easily the next time. The more a synapse is used, the better synapse it becomes, and the better linkage it provides between some stimulus and some response. The cortex is the place where linkages are made in the process of learning, and it is there also that forgetting, or atrophy, takes place through disuse. Exercise makes a synapse closer, disuse lets it relapse into a loose and poorly conducting state."[2]

Limitations of the Law of Use.—The law of use has never purported to explain how associations are originally formed. We may now attempt to point out other limitations, and some inconsistencies as well. Some other factors seem to be necessary besides the mere exercise of a specific reaction-arc to improve the strength of the association. To illustrate, we may quote Professor Woodworth's account of the incident that occurred in a Swiss psychological laboratory: "There is a famous incident that occurred in a Swiss psychological laboratory, when a foreign student was supposed to be memorizing a list of nonsense syllables. After the list had been passed before him many times without his giving the

[1] Woodworth, R. S., 'Psychology, a Study of Mental Life,' p. 389–390.
[2] *Op. cit.*, 414–415.

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expected signal that he was ready to recite, the experimenter remarked that he seemed to be having trouble in memorizing the syllables. 'Oh! I didn't understand that I was to learn them,' he said, and it was found that, in fact, he had made almost no progress towards learning the list. He had been observing the separate syllables, with no effort to connect them into a series." [1] Such facts show that the law of use is not a safe law to depend upon in practical affairs. This foreign student was repeating the nonsense syllables in the proper order, but although there was much exercise, there was little learning. Obviously, then, his practise was not of the proper kind, and the claim might be made that he did not exercise the proper neurons. Immature students sometimes follow the lines of a printed page without knowing very much about the material covered. Studies on the 'value of recitation' also illustrate the fact that something else besides mere repetition is necessary. It is claimed that the student must intend to learn the material, must have the will to learn, and be interested in the task. These considerations show at least that the mere outward performance of an act is not necessarily an accurate indication of the amount of strengthening of the connection between the stimulus and the response.

The Analogy of the Muscle.—It is commonly said that the exercise of a mental function improves the mental function, just as the exercise of a muscle improves the muscle; but this does not seem to us to be an accurate statement. We wish just now mainly to stress the fact that *outside factors* influence the muscle. Some products are brought in and other products are taken out, so that the muscle is not left in exactly the same condition as it was before. In fact, it is not exactly the same muscle. The popular statement ignores these important outside influences. The intrinsic and extrinsic muscles of the eye do not improve with exercise. The outside factors in some cases may cause muscles to become weaker rather than stronger, as when the athlete 'goes stale.' Fatigue may mask the desirable effects, while strain and overexertion may completely destroy them. Exercise does

[1] *Op. cit.*, 346.

not ordinarily improve many organs and functions of the body, *e.g.* swallowing, coughing, sneezing, breathing, heart-beat, winking, child-bearing, etc. Sense organs also do not continue to improve with practise and age.

It has been claimed that practise on a typewriter improves the typewriting; but we know that the function at the end is quite different from the function at the beginning of a distributed practise of, for example, 200 hours. It is true of course that the subject has a typewriter before him during all of the practise, he is in a sitting position, he may be using his hands, etc.; but different methods are used and different attitudes are taken; the specific reaction-arcs are different at the beginning and at the end. Some other processes must be considered in order to explain satisfactorily the improvement in typewriting besides the mere exercise of the original specific reaction-arcs.

Improbability of the Physical Mechanism Postulated for the Law of Use.—The law of use does not hold in biology generally, and it may be readily seen that the physical sciences also afford no data which illustrate it. For example, after electricity has passed through a copper wire, the wire is generally in no better shape to conduct the second time—in fact, it may be in slightly poorer shape. The force of gravity produces no greater effect on an object the second time. If the strength of the electrical attraction between two bodies is affected, then one or both of the two bodies (or the relation between them) must have been changed.

The experimentally demonstrated facts of nerve physiology also do not indicate that an impulse will pass across a synapse or along a nerve trunk any better the second time. Use seems to make very little difference, and certainly not enough to account for the speed of learning and the improvement in various functions, which are commonly observed. The work of C. U. A. Kappers and others on neurobiotaxis shows that the mere exercise of a specific reflex arc does not improve the arc. Stimulation is necessary for the *growth* of nerve fibers, to be sure, but the stimulation comes from the *outside* rather than from the *inside* of the specific reaction-arcs involved.

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Exceptions to the Law of Use.—The experiments on the conditioned reaction and negative adaptation afford numerous exceptions to this law.[1] In Pawlow's well-known experiment, it was observed that the dog's saliva would not continue to flow with repeated repetitions of the bell stimulus. Several others have made a similar observation. Some very familiar examples of the same thing are also available from everyday experience. Suppose that an association is formed between a snake and a fear reaction, in a child. Now if this child in later life catches snakes and plays with them and operates on them, etc., this fear response will in all probability degenerate; but, according to the law of use, the fear response should become more pronounced. A great many dislikes, aversions, fears, etc., are broken down in this manner. As in former illustrations, outside factors influence the specific reaction-arcs involved in the act.

The examples of negative adaptation are similar to those offered above. We are annoyed at first by the noise of the city, but may soon become accustomed to it. We hear the clock one moment, but are not aware of it the next. Some other factors are at work besides the mere exercise of the specific connections which were involved just after the connection was originally formed.[2]

The Law of Disuse.—This law is stated by Professor Thorndike as follows: "To the situation, 'a modifiable connection not being made by him between a situation *S* and a response *R*, during a length of time *T*,' man responds originally, other things being equal, by a decrease in the strength of that connection."[3] However, it may be pointed out that there is sometimes a strengthening and sometimes a weakening

[1] It is assumed in these illustrations that the stimulus and the reaction are already associated. What we wish to criticize is the assumption that use will improve these connections.

[2] Of course there are many *degrees* of strength of connections between stimuli and responses; and it is desirable to know something about the amount and extent of the association, as well as whether there is any connection at all. There may be *some* connection, to be sure, between stimulus *A* and response *B* which was learned some twenty years ago, but it would be somewhat arbitrary to say that there *is* or that there *is not* a connection between *A* and *B* at the present time.

[3] Thorndike, E. L., 'The Original Nature of Man,' p. 172.

of a modifiable bond, during 'disuse.' It may be either the one or the other; and the 'other things' are *never* equal. The bond is *not necessarily* weakened during disuse; and, if it should become weaker during disuse, it is not necessarily weakened because of the disuse, but because of outside factors which influenced the specific reaction-arcs. Fatigue products may be removed, and the bond may be *strengthened* during disuse. Time brings about changes in all organic compounds but the change is not necessarily for the *worse*. Furthermore, shock and the death of nerve cells, etc., may also weaken a connection, so that it is not always weakened *because of* the disuse.

Elsewhere, Professor Thorndike states the 'law of disuse' as follows: "When a modifiable connection is *not* made between a situation and a response during a length of time, that connection's strength is decreased. The explanations and qualifications stated in connection with the Law of Use apply here also."[1] Apparently, *all* of the explanations and qualifications which Professor Thorndike stated in connection with the law of use cannot apply to his statement of the law of disuse as well. We presume, however, that by 'a modifiable connection' Professor Thorndike has reference to a change in the strength of the bond. Stated in this way, the law cannot be correct, since during disuse the bond is *sometimes strengthened* by outside factors. Your eyes may seem weak tonight, and stronger tomorrow. You may be too tired to work just now, but rest will get you back in shape again. You may not be able to recall a name now, but may recall it all right in five minutes. Outside factors have an influence, and the strength of the bond is not necessarily decreased when it is not 'exercised.'

If by the statement, 'when a modifiable connection is *not* made between a situation and a response during a length of time, that connection's strength is decreased,' Professor Thorndike means that no bond is present at all, then of course the strength of that bond could not have been *decreased*, since it was zero at the start. If Professor Thorndike has

[1] Thorndike, E. L., 'The Psychology of Learning,' p. 4.

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reference to an antagonistic response, then it seems to us that the strength of the response in question would not be decreased; but, rather, the strength of the antagonistic response would be increased.

Professor Thorndike would doubtless apply the term 'situation' to the total condition of the organism, both internal and external, *all* factors being considered. Now if there is no change whatever in the relation between the total situation and the response—which of course must be most intimately related to the whole situation, and, in fact, be a part of it—we do not believe there could possibly be a 'decrease in the strength of the connection.' We agree with Professor Thorndike and others in the theoretical statement that the same situation always calls out the same response, and we therefore do not understand how it can be possible for the same situation to call out a different response in this particular case.

It is impossible to know just what is meant by some of the available statements of the law of *disuse*, and this is the reason that we have attempted to show: (1) that the law of disuse never has a chance to operate, (2) if it did have a chance to operate it would not operate as claimed, (3) if it did function it would function for a different reason than the one stated, and (4) if it functioned at all it might work in just the opposite direction from the one described.

It is apparently impossible to visualize the physical mechanism of the law of exercise. The law of use and the law of disuse are both contradictory and misleading. We must take account of other causal factors besides those present on the *inside* of the specific reaction-arcs.

3. The Law of Effect

In this section, we shall attempt to criticize the law of effect from various points of view. We shall (1) state the law of effect as formulated by Professor Thorndike, its leading exponent, (2) state and criticize one of the best examples of the practical operation of the law of effect, as given by Professor Gates, (3) criticize the law of effect from

the point of view of the psychology of feeling, (4) state and criticize the laws of readiness, which is part of the law of effect, and (5) attempt to show that some doubtful assumptions have been forced in connection with sensory pains. The law of effect has so many sides, and is so involved and technical, that it is difficult to give a well organized criticism. Throughout this section, however, we are always attempting to give evidence against the law of effect from one point of view or another.

The law of effect has been proposed as an explanation of the formation of associations. Pleasure is said to 'stamp in' the successful reaction, and displeasure is supposed to 'stamp out' the unsuccessful response. It is claimed that the satisfyingness and annoyingness of the act operate as selective agencies, eliminating the useless movements. Pleasure and pain are thus looked upon as substantive faculties exerting an influence on behavior. We believe that if these terms were defined in more scientific language much of our difficulty concerning them would disappear, and we would find that, after all, what we meant to describe were certain kinds of reactions of the human organism. It is very difficult to understand how two general *faculties* could operate so persistently in one body, and work antagonistically to each other. Few writers have attempted to describe the way these faculties are supposed to operate. The supposition that either the one or the other is always at work *when associations are being formed* has also not been justified. Reaction tendencies are sometimes modified with very little, if any, pleasure or pain.

We may quote the following statement from Professor Thorndike, which shows the influence of psychological hedonism: "Reason finds the aim of human life the improvement and satisfaction of wants. By reducing those to which the nature of things and men denies satisfaction, or by increasing those which can be fulfilled without injuring the fate of others, man makes his wants better. By changing the environment into a nature more hospitable to the activities he craves, he satisfies them. The sciences and arts arose by the impetus of wants, and continue in their service. They are

the ultimate source of all values. The original basis of the wants which so truly do and should rule the world is the original satisfyingness of some states of affairs and annoyingness of others. Out of such original satisfiers and annoyers grow all desires and aversions; and in such are found the first guides of learning."[1] We would prefer to say that the sciences and arts arose partly by the impetus of *activities* of the human organism, rather than by the impetus of *wants*. The wants are also not the ultimate source of *all* values, for many things are valuable which we do not want at all. Furthermore, the world is not ruled by 'wants.' Professor Thorndike holds, we think, erroneously, that the 'original basis' of wants is the 'original satisfyingness of some states of affairs and annoyingness of others.'

Satisfyingness and Annoyingness are defined by Professor Thorndike as follows: "By a satisfying state of affairs is meant roughly one which the animal does nothing to avoid, often doing such things as attain and preserve it. By an annoying state of affairs is meant roughly one which the animal avoids or changes."[2] A good many reactions of the organism would come under this category, but some of them would not be in the least 'satisfying,' as the term is used in popular speech. We are not at all aware of many of our physical activities. If Professor Thorndike means that the satisfying reaction is simply the one which the animal makes, then the application of the law of effect would be a circular argument: for the animal would then be said to make the reaction because it is satisfying, and a satisfying reaction in turn would be said to be the one which the animal makes.

Relation to the Psychology of Feeling.—The affections and the feelings have given some encouragement to those who believe in the algedonic theory. All feelings are said to be either pleasant or unpleasant; but there are numerous contradictions in the introspective work in this field; and we have at least some reason for believing that if feelings are present at all: (1) they may be 'mixed,' (2) they may at times

[1] Thorndike, E. L., 'The Original Nature of Man,' p. 123.

[2] *Op. cit.*, 123.

be more or less negative even in regard to pleasantness and unpleasantness, and (3) the feelings may be made up simply of sensations. Considerable difficulty has been experienced in identifying the physical 'correlates' of these processes, and it is generally understood that the whole subject of feeling is in a bad condition. Several people testify that when they are learning some things they feel neither pleased nor displeased, but just negative, and certainly all people must lapse into this condition at one time or another while the learning process is active. We may not have many feelings when we are reading, or they may even be unpleasant, but associations are being formed just the same. Feeling and learning are certainly not very closely correlated.

Illustration of the Operation of the Law of Effect.—Professor Gates has given a good illustration of the way the law of effect is supposed to work. Briefly stated, suppose three cats have been taught to come to you when you call them. Now call them individually. Feed No. 1, act indifferently toward No. 2, and throw a bucket of water on No. 3. 'Other things being equal,' Professor Gates says that the *law of exercise* will not apply, since the three cats will thereafter behave differently when you call them. No. 1 will probably come more surely and promptly. No. 2 will 'continue to respond for a while, but less promptly and frequently, finally failing altogether.' No. 3 will 'probably very promptly show a failure to respond.'[1] Discussing this behavior, Professor Gates writes as follows: "Apparently there is something about the *effect* which accompanies or follows an act that either reinforces or decreases the results of use or causes an animal to repeat the act in one case and avoid it in the other, or both. Pain, confinement, the holding up of a tendency under way, futile or wasteful work all tend to stamp out the reactions which they accompany or follow. On the other hand, reactions which bring release from confinement or pain, which bring food, kindly treatment, or attention, are repeated and stamped in more rapidly than when they are exercised with an indifferent result. It is the reaction which brings,

[1] See Gates, A. I., 'Psychology for Students of Education,' p. 227–228.

broadly speaking, a satisfying state of affairs, absolute or relative, that is repeated and stamped in quickly during use. The more satisfying the resulting state the more surely the reaction will be repeated and the more quickly stamped in. On the other hand, those reactions which are avoided or are stamped out even during the process of exercise, are the ones which are accompanied or followed by annoying states of affairs or annoying effects." [1] We admit that there is *something* which caused the changed type of behavior, but we do not understand how this could be the 'satisfaction,' used either in the popular sense (which is apparently the case in the above quotation), or used in the other sense, as existing in the mind. Professor Gates follows Professor Thorndike in the definition of satisfaction, stated above. The criticism which we suggested against Professor Thorndike's views applies also to Professor Gates': if satisfyingness is conceived as a disembodied entity, then the law of effect as it has been stated cannot be accepted; whereas if a satisfying state of affairs means just what the animal does, then this statement of the law of effect runs in a circle. We have yet to explain why the three cats changed their ways.

If the everyday concept of satisfyingness, satisfaction, pleasant, pleasure, agreeable, etc. is intended, in the discussions of the 'stamping in' and 'stamping out' effects, then we find equal difficulty in accepting the law of effect. We know practically nothing about the 'subjective' feelings of animals below man; and human learning shows many exceptions to this proposition, since so much learning is effected without any particular feeling tone being present. Certain writers claim that the most efficient learning is the 'unemotional learning.' Excitement and worry are not conducive to the best performances, they say. Now whether the 'pleasantness' is present or not, certainly the formation of associations is not dependent solely upon the presence of this pleasantness or unpleasantness, but upon *certain physical activities of the organism*. If pleasantness is defined in terms of physical reactions of a physical organism, then it may be said that

[1] *Op. cit.*, 228.

these reactions are not the *only* reactions which caused a change in behavior of the three cats referred to above. It is an unjustified assumption to suppose that *these* 'pleasantness' and 'annoyingness' reactions are *the* reactions which change the behavior, and that no other activities in the organism are *in the least* responsible for the modified reaction tendencies. If pleasantness is defined in terms of a dualistic psychology, as a non-physical entity, then we still have some difficulty in accepting the various statements of the law of effect.

Native Likes and Dislikes.—The reflex activities of the newly-born child tell us very little about the feelings which he experiences, if indeed he has any feelings at all. In a vague sort of way the feelings of an adult can be judged from his facial expression, etc., but in the case of the child just born, and in the case of animals below man, practically nothing is known about affection and feeling. The one-year-old child is very probably not particularly pleased when he waves his hands, nor particularly displeased when he cries. These are simply reflex responses, and it would be unscientific to judge his feelings by his behavior, especially since there is such a strong tendency to read your feelings into his acts. The 'conscious aspect' of various reactions seems to be built up very gradually, and it would be erroneous to suppose that the conscious reactions themselves are the sole determiners of all of the acts which are learned in the early years of infancy. Although the infant makes certain avoiding or defense movements, some of the stimuli which originally call out these defense movements may later call out responses which are pleasant. Likes and dislikes change in such a peculiar fashion from day to day.

In these days of skepticism concerning instincts, it seems plausible to the writer that conscious feeling reactions may themselves be learned. The likes, dislikes, pleasures, and aversions of people differ so enormously that no one would claim that they are *entirely inherited.* But, we may ask, what becomes of the *selective activity* of satisfyingness and annoyingness while the satisfyingness and annoyingness are themselves being learned? If satisfyingness and annoying-

ness are learned reactions, or just partly learned, then obviously the acquired satisfyingness and annoyingness could not possibly have been acting as a selective agency in *acquiring itself*. We have to conclude that satisfyingness and annoyingness are *completely inherited*, or that some other factors besides satisfyingness and annoyingness have been responsible for some or all of the learning which has taken place. All of the facts indicate that the latter view is the correct one.

A Concept of Readiness.—In considering the question of the elimination of useless movements in animals below man, some psychologists have pointed out that the rat in the maze cannot distinguish between the 'successful' and the 'unsuccessful' turns at the time he makes them, and of course a human subject in the same situation would have a similar difficulty. One turn looks like another to the rat at the time he makes it, and it is difficult to understand how the *successful* turn could have been 'stamped in' and the *unsuccessful* turn 'stamped out,' at the time they were made.

We return to a statement of this question by Professor Thorndike, who writes as follows: "Successful operation can in fact be satisfactorily defined, and what will originally satisfy and annoy can be safely predicted, only as a characteristic of the internal behavior of the neurons. By original nature a certain situation starts a behavior-series: this involves not only actual conduction along certain neurons and across certain synapses, but also *the readiness of others to conduct*. The sight of the prey makes the animal run after it, and also puts the conductions and connections involved in jumping upon it when near into a state of excitability or readiness to be made. . . . The activities of the neurons which cause behavior are by original nature often arranged in long series involving all degrees of *preparedness* for connection-making on the part of some as well as *actual* connection-making on the part of others. When a child sees an attractive object at a distance, his neurons may be said to prophetically prepare for the whole series of fixating it with the eyes, running toward it, seeing it within reach, grasping, feeling it in his hand, and curiously manipulating it." [1] We cannot agree

[1] Thorndike, E. L., 'The Original Nature of Man,' 125–126.

that 'what will originally satisfy and annoy can be safely predicted, only as a characteristic of the *internal* behavior of the neurons,' *i.e.* granted that anything will *originally satisfy*. Even if we should suppose that some things are originally satisfying or annoying, we would certainly not limit the total process to the *internal* behavior of neurons. It is a problem of the future even to show that conscious reactions are entirely dependent upon activity *in neurons* or in nervous tissue. The stimuli, sense organs, nerve-trunks, the nature of the synapses, muscles, glands, etc. must all be considered. In the statement quoted above, Professor Thorndike fails entirely to take account of the fact that *afferent impulses frequently come from muscles, thereby influencing behavior.* According to Professor Thorndike's view, we wait for an *instinct* to start the behavior-series; and then this instinctive activity changes the 'readiness to conduct' of other reaction-arcs. While it is true that activity in reaction-arc A may cause impulses to *pass through* reaction-arc *B*—chain reflexes, circular reflexes, etc.—and while activity in *A* may even alter some of the synapses in *B*, there are a great many exceptions, and sometimes it does not work the 'right' way: *B may be* inhibited rather than innervated. Professor Thorndike's statement suggests that the neurons always operate in some unusual way to bring about a *successful* result. Neurons, as far as we know, behave in strict accordance with physical and physiological laws; and a vitalistic assumption is unwarranted and unnecessary even in the present state of our knowledge of nerve physiology.

We should apparently not let the matter rest here, for Professor Thorndike goes on in the next few sentences to say: "The fact is that it is the neurons, not the body as a whole, whose life processes are primarily concerned in the 'successful' operation of a behavior-series. By 'normal' or 'successful' operation we mean the externally observable signs of the action of neurons that are ready to act. And by the failure, or thwarting, of an original tendency we mean the observable signs of failure to conduct and connect in neurons which are ready to act." [1] We might contract the first two sentences to

[1] *Op. cit.*, 126–127.

read as follows: "Not the body as a whole, but the life processes of the neurons, are primarily concerned in the externally observable signs of the action of neurons that are ready to act." Or, still more briefly: "The neurons are primarily concerned in behavior due to the action of neurons." More briefly still: "Neurons are concerned in the effects of neurons!" In the meantime, the question of the 'successful' response has been sidetracked.

The Law of Readiness.—This is stated by Professor Thorndike as follows: "The essential satisfyingness [1] in these cases is then the conduction along neurons and across synapses that are ready for conduction and the essential annoyingness [2] in these cases is the absence of such conduction." [3] Professor Thorndike states further that this law 'holds good not only in the case of such definite behavior-series as feeding, hunting, fighting or sex-indulgence, but throughout behavior.'

The Laws of Readiness and Unreadiness.—Let us quote Professor Thorndike again: "I believe that the original tendencies of man to be satisfied and to be annoyed—to welcome and reject—are described by these three laws of readiness and unreadiness:—(1) that *when a conduction unit is ready to conduct, conduction by it is satisfying, nothing being done to alter its action,* (2) that *for a conduction unit ready to conduct not to conduct is annoying, and provokes whatever responses nature provides in connection with that particular annoying lack;* (3) that *when a conduction unit unready for conduction is forced to conduct, conduction by it is annoying.*" [4] We may consider these three laws separately:

(1) So little is known about the physiological basis of the feelings of pleasantness and unpleasantness that it is some-

[1] According to Professor Thorndike, "Samples of original satisfiers or instinctive likes are:—*to be with other human beings rather than alone, to be with familiar human beings rather than with strange ones, to move when refreshed, to rest when tired, to be 'not altogether unenclosed' when resting at night.*" (*Op. cit.*, 123.)

[2] For Professor Thorndike, "Samples of original annoyers or instinctive aversions are: *bitter substances in the mouth, being checked in locomotion by an obstacle, being hungry, being looked at with scorn by other men, the sight and smell of 'excrementitious and putrid things, blood, pus, entrails.'*" (*Op. cit.*, 123.)

[3] *Op. cit.*, 127.

[4] *Op. cit.*, 128.

what premature to conclude the matter so abruptly and to say that when a conduction unit is 'ready' to conduct for *it* to conduct is satisfying to the *organism as a whole.*

(2) It is highly improbable that the failure to conduct of a 'conduction unit'[1] is annoying. If by readiness is meant merely a physical state, then surely failure to exercise this *particular connection* would not cause displeasure to the *whole organism*, for consider all the neurons in the cerebrum that are lying 'idle' and 'waiting' for the proper stimuli to call up memories and facts which have been learned in the past. The only other alternative is to attribute *human* qualities to the conduction units, and to think of them as 'ready' or 'not ready,' just as when we say 'I am ready to go' or 'I am not ready to go.' We hesitate to believe that Professor Thorndike would advocate such anthropomorphism as this.

Now suppose that one conduction unit in the body is ready to conduct and conducts; and suppose further that (while this is happening) another conduction unit in the same body is not ready to conduct, but conducts just the same. That is to say, suppose that satisfyingness and annoyingness are produced at the same time and in equal quantities, then, we may ask, does one smother the other, or is the effect somewhat like the component action of several forces? Satisfyingness is said to be 'what the animal tries to attain' (positive tendency), and annoyingness is said to be 'what the animal tries to avoid' (negative tendency). Although the animal may be torn by these two tendencies, he could not be in two places at once, and we have to conclude that no 'effect' would be produced in this hypothetical case, although one conduction unit was ready to conduct and conducted and the other conduction unit was not ready to conduct but conducted just the same. 'Readiness to conduct' would apparently not *always* produce an 'effect.'

(3) To force a conduction unit to conduct when it is 'not ready' to conduct! Either the criticism in regard to anthropomorphism applies here or Professor Thorndike must conceive readiness in purely physical terms. If the latter is

[1] 'Neuron, neurons, synapse, synapses, part of a neuron, part of a synapse, parts of neurons or parts of synapses.' (*Op. cit.*, 127.)

the case, then we do not understand how a conduction unit could possibly be *forced to conduct* when it is *not ready* to conduct. If the conduction unit is in proper shape to conduct, assuming that it gets the stimulus, it *will* conduct; and if it is not in proper shape to conduct, assuming again that it gets the stimulus, it *cannot* conduct. We may once more use the analogy of the copper wire, which *will* conduct an electric current if certain physical requirements are met; but if these physical requirements are not met, for example, if the wire is broken, it *will not* conduct. There is no such thing as forcing this wire to conduct 'against its will.' It is exactly the same with the reaction-arcs of the human machine.

Sensory Pains are considered by Professor Thorndike as simply one class of annoyers.[1] "It is necessary to suppose that the conduction units whose action causes sensations of pain are almost always unready to conduct." [2] But some pains are welcomed as the lesser of two evils, for example, "A man knowing that pain in his eyes would mean that he was cured of threatening blindness might well cherish that pain when it came." [3] In such a case as this, however, Professor Thorndike says that "We should expect that the conduction units concerned *would* be made ready." In ordinary conditions, therefore, if a man experiences a pain, "the conduction units whose action causes sensations of pain are almost always unready to conduct"; but if the man welcomes the pain, as in the above illustration, Professor Thorndike assumes that these same conduction units, whose action causes sensations of pain, are now *ready* to conduct. These neurons, according to Professor Thorndike, carry *pain impulses* regardless of whether the man welcomes or avoids the pain, but in the one case they are ready to conduct and in the other case they are unready to conduct! According to Professor Thorndike, the *readiness rather than the pain determines the man's behavior*, in such cases as these.

We are unable to visualize the (physical) mechanism which could mediate or cause this peculiar kind of behavior.

[1] *Op. cit.*, 124, 128–129.
[2] *Op. cit.*, 129.
[3] *Op. cit.*, 129.

Why should reflex-arcs *continue* to conduct pain impulses if they are 'unready to conduct'? As a matter of fact, some of these neurons seem to be fairly efficient in conducting pain impulses, as in the case of those neurons which conduct pain impulses from the teeth and ears. It is difficult to conceive of these neurons as *unready* in any sense of the word. Furthermore, the pain receptors, probably the intraepithelial nerve-endings, are *very sensitive organs*. The well-known phenomenon of sensory adaptation is *practically absent* in the pain sense. Sensations proceeding from the pain organs are *not necessarily* painful in the sense that they are disturbing or unpleasant. The blending of sensations of pain with sensations of pressure and temperature affords another interesting problem.

Professor Thorndike admits that there is no conclusive evidence for his assumption, but says that *some* evidence is furnished by the fact that reaction-time to pain is slow. It seems to the writer that *all* of the available evidence is on the side which is against this theory. The *speed* of a reaction is not a true indication of the 'readiness to conduct,' which is said to determine the satisfaction, which in turn is said to determine the learned behavior. According to this view, all learned behavior would be a function of the speed of conduction in reflex-arcs. Reaction-time is dependent upon a variety of factors: as, for example, the nature of the receptors, the number and length of the neurons involved, disturbing elements (such as would be present in sensory pains), etc. Furthermore, some slow activities in the body are pleasant and some fast activities are unpleasant. Various activities go on in the body with various speeds, and we are not at all aware of many of them. It is very difficult to understand how speed could be so closely correlated with 'readiness' in some neurons but not in others.

The law of effect is in no way a plausible explanation of association and learning. The principal fallacy in Professor Thorndike's statement of this law is the premature attempt to describe the physical basis of the 'awareness of pain' and the 'awareness of pleasure.' Psychology is not yet ready to give a plausible explanation of such experiences.

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4. Conclusion

We may now attempt to give a brief summary of the preceding paragraphs:

1. The law of use, which states that the exercise of a function improves it, is faulty in the following respects: (*a*) it ignores the outside factors which influence the specific reaction-arcs, (*b*) it does not always operate as claimed, and (*c*) it is impossible to conceive of the physical mechanism involved.

2. The law of disuse, or the general principle of atrophy through disuse, has been rejected for practically the same reasons as the law of use. In discussing learning problems, it is necessary to take account of other causal factors besides those present on the inside of the specific reaction-arcs.

3. The law of effect, which purports to explain the formation of associations, is based upon psychological hedonism. This doctrine can no longer be justified from the side of philosophy.

4. Satisfyingness and annoyingness are conceived as substantive faculties exerting an influence on behavior. They are said to act as selective agencies, stamping in the 'desirable' reactions and stamping out the 'undesirable' reactions. These propositions cannot be accepted.

5. Satisfyingness and annoyingness are said to be entirely inherited, and proper attention is not paid to those feeling reactions which are learned.

6. The laws of readiness and unreadiness are anthropomorphic. It is highly improbable that the readiness or unreadiness of certain specific reaction-arcs to conduct can influence the satisfaction of the whole organism.

The laws of exercise and effect have been used as fundamental concepts especially by those who are interested in the applications of psychology. Some of these writers claim that all influences of the environment on the individual operate through these laws; and it is obviously of importance to technical psychology as well as to educational theory and practise to be clear on these matters. We feel that

the criticisms which we have offered above are concerned with much more than incidental and arbitrary points of terminology.

The law of effect is based upon the insecure pleasure-pain philosophy, and postulates entities which have no existence in fact. It is mentalistic and anthropomorphic, and forces those who believe in it to accept some very doubtful propositions in connection with sensory pains and the psychology of feeling.

It may seem to the reader that we have been somewhat impolite in thus criticizing two important laws of learning, without suggesting anything in their place. Probably no theory of learning can be entirely justified at the present time; and we could not even make an attempt at such a justification in the space which is here available. We are convinced, however, that the theory which will eventually be evolved will be one which breaks completely with mentalism and the pleasure-pain philosophy. For a theory of learning to be scientific, it must take proper account of what is known about nerve physiology, and the physical and chemical relations of the organism.

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THE RISE OF OBJECTIVE PSYCHOLOGY

BY V. F. CALVERTON

Editor of the Modern Quarterly

Comte was not the first to maintain that psychology could never develop into a science. Nor was he the last! It is curious to note the numerous shiftings of opinion made by so many philosophers in this argument. In the entire problem, however, there has been rarely, if ever, a clear defining of the issues, and in no case an attempt made to describe exactly what is supposed to be science and what not. A floundering in hazy and meaningless terminology has resulted, with no definite advance in objective knowledge.

Lange put the difficulty quite succinctly in his 'History of Materialism,' and a quotation from his statement on the subject is distinctly pertinent.

"In psychology we can undertake no dissections, can weigh and measure nothing, can exhibit no preparations. Names like thinking, feeling, willing, are mere names. Who will point out exactly what corresponds to them? Shall we make definitions? A treacherous element! They are of no use, at least for any exact comparisons. And with what are we to connect our observations? With what measure shall we measure? In this groping in the dark it is only childish prejudice or the clairvoyant impulse of the metaphysician that is sure of finding anything. The understanding has only one way: it can only compare the positive, attested, observed actions of the animal world with their organs. It must resolve the question into the question of modes and causes of motion."

The problem, though not realized by most, immediately resolves itself into a discussion of the nature of objective and subjective knowledge and their relations to science. Objective knowledge, loosely described, is that knowledge which is acceptable by all, that is universal, and true for all time. Subjective knowledge, loosely described, is personal knowledge,

knowledge that is not acceptable by all and hence not universal, and does not have to be true for all times.

Knowledge must be defined as ideas of objects; the objects, it is assumed, are those things, in fact all things, that exist outside of us and can affect us, and ideas the mental replica of these objects in the brain in such a way that awareness of their existence results. Essentially, then, all knowledge is subjective, since whatever is known must be known first through individuals, that is, personally, before it can attain an objective status. The most objective piece of knowledge in the universe is none the less personal or subjective in its acceptance by every individual. Whatever is known, of course, working from a purely Lockian basis, must be known by sensitive things; we cannot conceive of insensate things, matter itself in other words, having knowledge, and therefore it follows that were it not for sensitive things there would be no knowledge, as we define knowledge, in the world.

To the degree that men can acquiesce as to the nature of an object does the knowledge of it become 'objective.' What is strictly meant is that we get close enough to the object to derive sufficient knowledge of it for all men, able to get the same knowledge, to agree as to its nature. With what is usually called subjective knowledge this is not true. Now what is it that distinguishes objective knowledge from subjective? *The object is there in either case*; it must be there in all cases, or there could be no knowledge. But in the one case we are able to come to definite agreement as to the major qualities of the object—it must be observed here that that does not include the 'why and wherefore' or the *ding an sich*—while in the other there is wide, personal disagreement, or what is commonly known as subjective opinion.

The difference between objective and subjective knowledge is due to the fact that in the former there exists an accepted system of coördinates or means of measurement, while in the latter no such means are at hand—and there are important reasons why they are not at hand. This point requires further illustration. A picture exists just as definitely and precisely as the moon; a piece of mica is fundamentally no

more definite an object than a phrase or symphony concert; they are all objects capable of affecting us. It is true that the effects of a picture or a symphony concert upon the nervous system are more complex than the effects of the moon or the mica, but that does not mean that they are not just as much open to study as the former.

Let us raise the question again as to why the knowledge of the moon, the mica, or the gravitational tendency of the universe for further example, is viewed as objective, and the knowledge of the picture, the symphony concert, and, to add another instance, the religious impulse, is viewed as subjective. The solution is simple. In the first case we have knowledge that can be got in a uniform manner by all with no chance of disagreement, while in the second case the knowledge is not got in a uniform manner and as a consequence is conceived differently and is held to be subjective. The knowledge in the case of the moon, the mica, gravity, etc., is got the same by all because they have definite measurements with which to work. In other words, they can measure the breadth, length, and thickness of the object because they have metric or linear scales as an accepted basis. They can tell the compressibility or expansibility of an object because they have definite coördinates from which to compute. They can tell 'objectively,' if you will, the nature of visual reaction with opthalmoscopes and the character of kidney function with cystoscopes. They can tell exactly how far an amœba will move by means of micrometers or what paths an electron follows by an electroscope. Only by these methods could science have progressed to the place that it has. All knowledge comes through comparison and without these means of measurement comparison could never be made exact, and that means acceptable by all. Were it not for the micrometer, for instance, knowledge of how far a certain amœba moved under a certain stimulus, or what size it assumed when it encysted would still be subjective things, varying with the personal observations of each biologist. Disagreements as to the respiration or even the heart-beat of a certain patient would be just as subjective, or variant, among doctors, were

it not for the exact measurements of the stethoscope. It is only an accepted system of coördinates, then, that can make possible exactness of comparison, or, in other terms, objective scientific knowledge.

The advance of science will be determined by its ability to get all objects down to an objective basis. The main purpose of science is to be able to predict; given the object and the receptor it must aim to reach the point where it can predict the reaction. It can do that now with many of the reactions of matter; with each addition to its knowledge it approaches closer to its goal. It must be admitted that measurement itself is a premise, but it is a premise accepted by all because of its inevitability. It is possible, to be vexingly ontological for the moment, that both form and substance are illusions. But working from a realist or materialist basis, which is the only scientific and logical one, measurement by exact coördinates is the only route that science can follow.

Of all things that have caused befuddlement and confusion, and that have made psychology unable to get to an objective basis, the term 'consciousness' is supreme. There have been more definings of that term than any other, and, to quote Engel's ingenious phrasing, since "each one's special [definition] is again conditioned by his subjective understanding, his conditions of existence, the measure of his knowledge and his intellectual training, there is no other ending possible in this conflict of [definitions] than that they shall all be mutually exclusive of the others."

There is the naïve conception of consciousness that things in the mind are an exact replica of reality; the dualist conception of two worlds, the mental and the physical, and that consciousness, obviously consisting only of the mental, has a different picture of things than they really are; the critical realist conception, the idealist conception; the solipsistic, etc.; all staunchly maintained by their respective advocates, and each with its own peculiar logic. None can be said to be positively wrong since there is no way to get definite knowledge of what consciousness is, that is, providing we assume it to exist in the fashion that the usual metaphysician

does. It may be a thing existing in all cells, as some have maintained, or a thing—what a vague word!—peculiar only to the cerebral cortex as Gall first pointed out, and as most physiologists and psychologists now contend. At any rate, it is a thing as unmeasurable almost as the first cause, and pursuing the road psychology has trodden from the time of Aristotle to that of Titchener, that is, the introspective, it will get no closer to objective knowledge than it had got at the time of John Locke.

Moreover, since consciousness itself is but the product of stimuli, and since, to follow radical determinist psychology, all thought is determined or reflex, consciousness is but the coördinate center of nervous impulses, and needs to be given no more consideration than is given the usual heart-beat or rhythmical segmentation of the intestinal system. Since consciousness does not control behavior it is a fallacy to magnify it into a bugaboo barrier. To use Watson's figure, consciousness is merely the shadow of leaves upon the ground. It receives and transmits impulses, interfering in no particular. Consciousness is caused by the same thing that causes behavior, namely, the functioning of the nervous system.

Behavior, on the other hand, can be observed and measured. In this way we can come to exactness, to scientific method. By this means psychology can become a science, and defy Comte's dictum. Notwithstanding how real an object is, no scientific examination and criticism of it are possible until a definite system of coördinates is accepted.

The psychology that at present is pursuing the scientific method indicated in this article, the only method possible if psychology is ever to be founded on a basis as objective as that of physical science, is commonly known as behaviorism. It is necessary to remark here that hints of the behaviorist method, with actual attempts in that direction, are to be discovered in many of the various texts on psychology and philosophy that were written during the last three centuries. Perhaps the most striking of these was that made by Johann Nicholas Tetens, who in his *Philosophische Versuche* (1777) endeavored to found an independent psychology which should

be entirely based on observation and experiment. Tetens, in the beginning, attempted the measurement of images produced by different sensations, but later veered sadly from the materialist method. Behaviorism is a philosophy as well as a psychology, notwithstanding the devout attempts of some behaviorists to avoid anything like philosophic concepts. It is a scientific philosophy, if you will. Carried to its legitimate limits it is a mechanist philosophy, that bases all of its conclusions upon observation and experiment. It carefully and meticulously avoids all voluntarist metaphysics. It eschews any reference to 'consciousness' or a 'conscious process.' Sufficient reasons were given above for this. Any mention of an *élan vital* is obviously taboo. A stimulus-response psychology, as it has been frequently described, views all action as a response to stimulation—a response is the total striped and unstriped muscular and glandular activity that occurs as a result of stimulation. A brain never gets into action save through a sense organ; it is necessary to note here that every muscle besides being an effector is also a sense organ. An emotion is an inherited 'pattern-reaction' involving profound changes of the bodily mechanism as a whole, but particularly of the visceral and glandular systems. Emotion appears at time of emergency. It is the organization of visceral activity in an emotion that tends to give the additional drive and energy to the body—the blood pressure, for instance, is raised and the blood tends to coagulate. Emotion and instinct are differentiated by patent variations in behavior.[1] The shock of an emotional stimulus throws the organism, for the moment at least, into a chaotic state, and during that moment it can make few adjustments to its environment; in the case of instinct, which involves the striped muscles, that indecision and chaos do not result, and, minus the diffuseness of an emotion, the action is specific and definitized. In specific activity, or instinct, you have little if any visceral involvement; in diffuse, at any rate less specific,

[1] It is important to note here that Professor J. B. Watson, the originator of modern behaviorism, and the psychologist who has undoubtedly made the most important contribution to American psychology, uses entirely the genetic method in his discovery and analysis of emotions and instincts.

activity, or emotion, you have unmistakable visceral involvements. All activity is fundamentally the result of visceral drive. The energy one embodies, for instance, is derived from persistent stimulation in the viscera; any type of activity tends, according to its vigor and pertinence, to reduce this tension, temporarily if the activity is temporary, constantly if the activity is constant. Those kinds of activity that reduce the drive immediately are those that remove the stimulus. The conditioned reflex is used to explain the origin and persistence of habit. Mental abnormalities raise no insolvable difficulties for the behaviorist. Diseased personality arises from habit distortion. Manic-depressive psychosis, for example, is explained as the result of the advent of certain chemical (glandular) substances into the blood; in dementia præcox cases, where you discover certain tension, the hand-resting having a different appearance from normal and the arm being incapable of elevation without great tenseness, you have an absence of strychnine in the blood, or some other chemical element, which closes a number of the synapses and prevents free and non-antagonistic muscular activity.[1] It is in the matter of thought that behaviorism takes its most revolutionary stand. Thought occurs where a problem opens and visceral tension persists; it is purely cœnesthetic, each thought following the other in purely muscular manner. Thought, then, is a form of behavior, consisting of subvocal movements of speech muscles; every thought, therefore, must have a physiological corollary to determine it. Speech is a form of substitute behavior; speech movements are associated with ordinary movements and are thoroughly muscular in character. Speech, a direct method of lessening visceral tension, is reduced to a minimum as habits become established. Merely unpleasant speech behavior is eliminated

[1] In the matter of sex, it should be observed, behaviorists are quite Freudian in their interpretations. Wherever an organism makes a positive reaction towards an object it is because the object stimulates its erogenous zones, causing a state of tumescence (the individual in many cases is not aware of this)—the erogenous zones are the sex organs proper and any other tissues that become rigid—and whenever it makes a negative reaction it is because the object stimulates detumescence. Smoking, for illustration, affords pleasure because it stimulates the erogenous tissue, the lips, to a state of temporary tumescence.

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in the case of repressions. In brief, then, the examination of all reaction should be confined to physical methods, since they alone, based already upon accepted coördinates, can give objective knowledge, and explanation of it should be made entirely in physical terms.

That the whole philosophy underlying this objective psychology, so maligned often under the name of behaviorism, has crying and significant social meanings is too little appreciated even by its warmest advocates. It is the wicked tendency of the specialist, be he a physicist, geologist, histologist, or psychologist, to narrow his observations to the laboratory and limit his conclusions to his immediate science. In the fashion that the old historians devoted themselves to the mere discovery and narration of fact, the modern scientists too frequently venture no coördination of data that extend beyond the confined scope of their particular inquiry. Induction, as a method, is fruitless unless general conclusions of importance can be derived from the collected facts. The social philosophy of behaviorism has yet to be written. In a sentence, it is cause and effect psychology reduced to its lowest common denominator. This at once implies a deterministic interpretation of individual and social activity. With this arise the problems that surround the question of 'morals and determinism'[1] which frightened Renouvier long before Professor Jastrow. Since no response is possible without a stimulus, all of man's actions must be viewed as determined by the stimuli that come to him, that is determined by the kind of environment in which he lives. As Professor Watson indicated, could the son of a Pharoah at birth be removed across time and space and be reared along with other lads in Boston, it lies well within the range of probability that he would develop into the same kind of college youth that we find among other Harvard students; his reactions to situations, notwithstanding the difference in his ancestry, would be approximately the same as those of a native New England boy, and 'his chance for success in life

[1] For discussion of this see the essay 'Morals and Determinism' by the author, which appeared in Vol. 1, No. 4 of *The Modern Quarterly*.

would probably not be at all different from those of his classmates.' It is change of environment, or change of stimulus in simpler terms, that will bring about change in reaction. As a social philosophy the significance of this can readily be seen. Man, as LaMettrie accurately saw him, a reaction-machine, behaves differently, and better, in a good environment than in a bad, just as he is healthier in a sanitary environment than in an unsanitary. If the theory of evolution be correct, whatever we call heredity must at one time have come from environment, and must have been changed as environmental influences demanded, and must continue to be changed in this same way as long as life survives. In other words, since heredity must be a product of environment, it must be changed, no matter how gradually or swiftly, whenever the environment is changed.[1] No intelligent doctor will deny that if you change a baby's unhealthful environment to a healthful one, and continue the latter throughout his life, no predispositions to disease that he may have inherited will be given opportunity to develop. By an extensive change in environment, therefore, the method of an accurate social psychology, and not by selective interbreeding and cries for the *Uebermensch*, will an improved race be created. The details as to all of these changes have certainly not been *all* discovered. It is the purpose, however, and fundamental value, of an objective psychology to work toward an objective sociology.

[1] For further elaboration of this point see the author's essay on 'The Practical Metaphysics of Crime' in Vol. 1, Nos. 1 and 2 of *The Modern Quarterly*.